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A NEW INCANDESCENT LIGHT FOR MICROSCOPICAL ILLUMINATION.

By A. Ashe, Esq., F.R.M.S.

(*Read October 8th*, 1918.)

Figure in Text.

The Welsbach gas light has not been accepted with such favour by microscopists as an illuminant as might have been expected from such a powerful brilliant and white light. The reason, however, is very obvious. An image of the coarse structure of the web of the mantle being projected into the field of view destroys all evenness of illumination, whilst for high-power critical work the comparatively enormous area of the source of light is an additional and serious drawback to its use. If these disadvantages could be entirely overcome it is certain that we should then have a most welcome addition to our very limited means of illumination.

When the Welsbach light was first introduced, I carried out a number of experiments for the purpose of making a smaller and more concentrated light than that given by the upright mantle, the small inverted ones now so common not having been then introduced. To this end I constructed some miniature

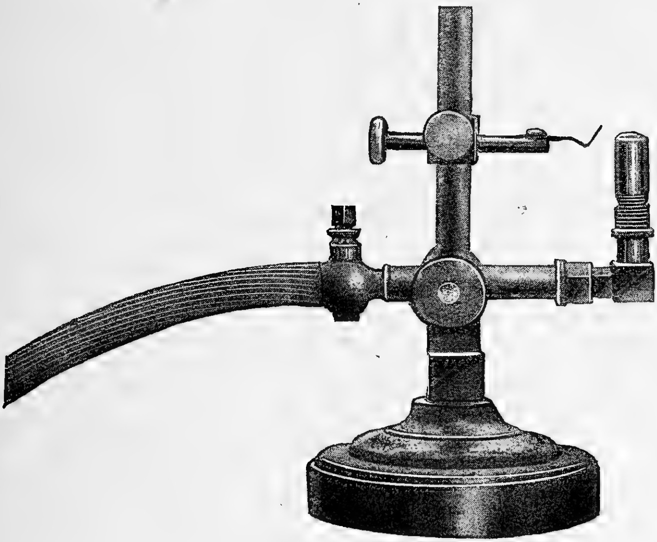
Bunsen burners, but none that I could make or purchase would produce a flame sufficiently small in size and high in temperature to attain the object in view; probably, also, the pressure of the gas supply was too low for the purpose. This failure, however, led to the making of trials with other forms of burner, and in the end I found that the burners employed in acetylene lamps, at that time coming into use, were, in their smaller sizes such as the 00000 made by Messrs. Bray, and passing about 1 cubic foot of gas per hour, far superior to any Bunsens which I could construct of similar power, and that such small burners gave when used with coal gas a perfectly blue and well-oxydised flame of high temperature well suited to the purpose.

A fragment of a mantle say about 1/4th inch square held in such a flame is raised to a high degree of incandescence and would be considered a brilliant little light, but the delicate nature of the mantle renders such a fragment quite unsuitable for repeated use and a more substantial substitute must be prepared.

This can be done by cutting an upright mantle into narrow strips about 1/4th inch broad, and 2 inches or more long, then rolling each strip round a knitting needle or smooth wire, securing the outer ends from uncoiling by means of a drop of gum or perhaps better still by wetting it with the tongue. The little rolls so made are slid off the wire and set aside to dry, though they can be used immediately if needed.

The lamp-stand may be of a simple description, consisting of a firm base from which rises a vertical rod to which is clamped a piece of 3/8 gas tubing, having the previously described burner at its outer end. Above this gas tube is separately clamped a horizontal rod tipped with a short length of platinum or nickel wire, its outer end being bent to an angle of 45 degrees upwards. Over this projecting wire is slipped one of the rolls by means of the little hole left in its centre when winding it round the knitting needle and a light then applied to the gas jet. (See illustration.)

To obtain the best possible result it is necessary that the roll be very carefully placed with regard to the flame, and for this purpose the burner must be raised or lowered or otherwise adjusted until the best effect is obtained, which, if properly done, should result in the production of a beautifully clear white light. It will be understood that coal gas alone is generally used for this light and that the higher the pressure the whiter the colour;



anything under 4 inches is unsatisfactory. Of course it may be used in conjunction with oxygen, when its brilliancy is re-remarkable bearing in mind the small quantity of gas used.

This method of illumination I have used with great success and satisfaction for more than fifteen years both for photographic and visual work, and only find it necessary to revert to limelight or oil when special circumstances demand them.

I wish by no means to make exaggerated claims on behalf of this light, but am sure that any who try it will find it a most cleanly, useful and economical source of light. Though by no means perfect, its advantages are sufficient to warrant further improvement at the hands of those who can do so.

In conclusion I would suggest that attention be given to some method of overcoming the drawback of the uneven surface of the roll, although this is very much less apparent in the field of view than when the ordinary plain mantle is used.

Note.—Since the above was written, I have pleasure in adding that Mr. Traviss has succeeded in preparing discs of Thoria which give a perfectly even illuminated surface, and are less fragile than mantles. They can be used for critical purposes, and he has by this improvement quite overcome the weak points in my lamp.

OBSERVATIONS ON CAPILLITIA OF MYCETOZOA.

By A. E. Hilton.

(*Read November 12th*, 1918.)

The resemblances of Mycetozoa to the Fungi with which they were formerly grouped are most apparent in the structure of their sporangia. In the amoeboid, plasmodium stage, which precedes spore-formation, all likeness to Fungi is absent, that phase being the distinctive peculiarity of Mycetozoa; but when the creeping plasmodia come to rest, and form up into fixed receptacles containing spores, their features so far correspond with those of certain Fungi that a terminology, including the words "sporangium," "capillitium" and "columella," is applicable to either. In both of these groups the term "capillitium" denotes thread-like tubes or fibres associated with masses of spores within a sporangium. The origin of such filaments, in the case of the Fungi, is partially elucidated by processes occuring in Lycoperdaceae, concerning which it is stated by de Bary that in the spore-bearing receptacles there are numerous delicate tubes or hyphae which ultimately become dry by evaporation of water, and so form "a woolly mass of loose texture, the capillitium, the interspaces of which are filled with large quantities of a dry powder, the ripe spores." *

As regards the capillitia of Mycetozoa, it is evident that the formative processes have many modifications. For so small a group the variety is surprising. The capillitial threads may be rigid or flexible—they may lie freely among the spores, like elaters, or be attached at either end to the walls of the sporangium

* *Comp. Morph. and Biol. Fungi, Mycetozoa and Bacteria,* by A. de Bary, 1887, p. 310.

or to a central columella—they may be solid or tubular—simple and unbranched—sparingly forked or freely branching—or branching and anastomosing into a network superficial or otherwise—and this network may be either inelastic or expansive. Furthermore, a capillitium may be plain or ornamented. In sporangia containing calcium, the capillitia are usually beaded or encrusted, and sometimes thickly covered, as in the genus *Badhamia*, with deposits of lime. The elater-like threads of the Trichiaceae, which are without lime, are generally marked with spiral bands, giving them a twisted, rope-like appearance; in Arcyriaceae we find expanding networks decorated with minute prominences arranged discontinuously along the threads of the meshes in a more or less spiral sequence. On the other hand, there are several genera in which a capillitium is either not present, or but imperfectly developed; while in a few species it is wholly absent, the cavity of the sporangium being entirely filled with spores, and the walls quite destitute of any elements of a capillitial nature.

In regard to utility, it is commonly held that the capillitia of Mycetozoa are supporting structures, or that they assist in the dispersal of the spores; but these ideas are apt to mislead. It is true the sporangium walls are in many instances connected with rigid capillitia, and that hygroscopic threads help to scatter the spores; but as some sporangia are without capillitia of any kind, it is clear that these factors are not indispensable. A sporangium needs to be fragile rather than firm, so that the spores may escape; and hygroscopic threads or expanding networks cannot possibly scatter spores so effectually as wind or rain, insects and birds. Indeed the surface nets of *Stemonitis* often impede, rather than facilitate, the dispersal of spores.

In studying Mycetozoa it must always be borne in mind that a sporangium of this group is not, in any proper sense of the term, a plant. It does not *grow*, in the ordinary botanical meaning of the term. When a plasmodium matures and comes to rest, its growth ceases; and the developing sporangia into which it then changes are but aggregates of plasm rapidly assuming sporangial shape in virtue of excretions, secretions, condensations, precipitations and interior and exterior surface-strains. If this is forgotten, and Mycetozoa are studied in a purely botanical light, misinterpretations are inevitable.

It follows from this that the capillitia of Mycetozoa have their origin in the character of the processes by which the plasm of an amoeboid plasmodium is converted into the plasm of innumerable spores. This transformation has a double aspect. It is not only a rearrangement of constituent elements; it is likewise a renewal of vital energy. That, indeed, is its real and primary significance. The breaking down of the plasm into multitudinous particles is at the same time a process of rejuvenation by elimination of waste materials. In creeping among rotting vegetation on which it feeds, a plasmodium absorbs various substances, chiefly in solution, which along with by-products of metabolism must be removed before the reproductive powers of the plasm can be regained. When these substances have accumulated until a critical stage is reached, the plasmodium aggregates and becomes stationary, and elimination proceeds apace. The coarser excretions are precipitated as a hypothallus or substratum, or deposited as a stalk or columella; other exudations at the surface of the plasm harden into enclosing walls of the sporangium; and interior secretions usually furnish materials of a cellulose nature which consolidate into a capillitium. While a capillitium is forming, the plasm-mass in which it is embedded shrinks in volume by the loss of exuded fluids and solids, and divides and redivides into smaller and still smaller portions, each of which in turn tends to become rounded by surface-tension; and it is important to notice that development of the capillitium proceeds along the channels produced by successive cleavages and contractions of the plasm-masses. In the end, after the capillitium has been deposited, the plasm arrives at an extreme state of subdivision in which each particle includes a single nucleus; and by a final act of excretion every nucleated plasm-speck clothes itself with a protective envelope, and becomes a complete and separate spore.

The recognition of this coincidence between successive bipartitions of the plasm, and the progressive formation of a capillitium along the chief lines of cleavage and contraction, is a long step towards a comprehension of the more obvious features of the capillitia of Mycetozoa; but it is not possible, even if it were desirable, to determine in detail the processes by which the minuter characteristics of the threads are brought about. Shrinkage in drying plays a conspicuous part; but the more obscure forces at work belong to the order of molecular physics. The results are variable. "It is an open question," remarks Mr. Massee, "as to whether ornamentation of the capillitium threads is of generic value, even if constant, as supposed by Rostafinski, but such is certainly not the case." *

About the middle of October 1915 a good gathering of rising sporangia, found on a tree-stump near the Cockfosters end of Hadley Woods, gave me a rare opportunity of watching the development of *Lamproderma columbinum.* When discovered at 2.30 p.m., the sporangia were about 1/8th inch high. The plasm was watery-white and transparent, and at the base of each sporangium a stalk was beginning to show. By 5.30 p.m. the sporangia were turning colour, becoming slightly brown and less transparent. At 7.0 p.m., under the microscope, a capillitium could be made out; and during the next hour or so this progressed considerably, branching and rebranching in a curiously intermittent way, and growing finer and more delicate as it proceeded. To look at, the process was singularly like the growth of a crystal by rapid but discontinuous accretions in a supersaturated solution; and similarly, the precipitation in this case was doubtless due to evaporation of moisture. By this time, although the plasm was still fairly transparent, its outer surface was becoming wrinkled by the excretion of a membranous sporangium wall; and the later development of the

* *A Monograph of the Myxogastres,* by George Massee, 1892, p. 141.

capillitium was thus gradually obscured. By 9 p.m. the colour of the sporangia had deepened, indicating that spores were forming; and an hour later it had changed to a reddish brown. Next morning, the sporangia were black; and by evening on the following day were of a shining bronze-like appearance, which they retained.

From records of other observations,* it appears that the elater-like threads of *Trichia* and *Hemitrichia* originate within the plasm as vacuolar spaces which gradually become longer and narrower until they traverse the sporangium in regular rows. These lengthened vacuoles, containing substances in solution, are at first nodular and uneven; but as development proceeds they become uniform, and a membrane is excreted by the vacuolar fluids which forms the tubular wall of the capillitial thread. On the outside of these membranous tubes further material is deposited in the form of spiral bands, giving them their twisted, rope-like appearance. The regularity of these spirals is probably the result of physical forces comparable to those of crystallisation but working in a coarser medium. Contractions in drying render the spiral bands more prominent, and wrinkle the underlying membrane so as to produce slender ridges appearing as very fine lines running lengthwise along the tube. When the sporangium wall is ruptured, the threads, which are hygroscopic, twist and intertwine into a fibrous tangle.

An interesting description of another of the TRICHIACEAE, *Cornuvia Serpula*, has been given by our fellow-member, Mr. J. M. Coon,† who found specimens of this minute species among spent tan in Cornwall. The capillitium consists of branching threads beaded at intervals with prominent ring-shaped thickenings. A stained preparation of plasm in which the threads were beginning to appear shows them to be tubular formations

* By R. A. Harper and B. O. Dodge. See pp. 388 and 389 of *Journ. R. Micros. Soc.*, August 1914, for abstract of paper published in *Ann. of Botany*, xxviii. (1914), pp. 1 to 18, 2 plates.

† *Journ. R. Micros. Soc.*, 1907, pp. 142–145, plates x. and xi.

with contents giving the effect of light and dark spaces, alternately arranged along the interior of the threads. Whether it is the light or the dark spaces which determine the positions of the future rings is not clear; but there is little doubt that the rings are formed by the tubes contracting in length and enlarging in diameter in either the dark or the light regions, the intermediate parts remaining as before. The process appears to be less complex than in other TRICHIACEAE, rings being simpler than spirals.

The expanding networks of the capillitia of *Arcyria* are usually ornamented with half-rings, cogs, spines, and other minute prominences, arranged more or less spirally along the threads of the meshes. These discontinuous markings are doubtless the outcome of processes similar in character, but less uniform in result, to those which produce the more perfect spirals of the TRICHIACEAE. The sudden expansion of the capillitium as a whole, when the sporangium walls give way, is not due to stretching, but to the straightening of bent and tubular threads of the network. In the developing sporangium, cleavage tracks with many curves traverse the plasm in all directions, the membranous tubes secreted along these channels form a network by frequent anastomoses, and when released the fibrous mass expands by the sudden unbending of hollow and flexible threads, and the consequent enlarging of the meshes of the net. After liberation the capillitium never returns to its former condition, but remains expanded.

In the genus *Lycogala* a modification is brought about in a very simple way. The plasmodium of the familiar species *Lycogala epidendrum* rises from the rotting wood as a cluster of coral-red protuberances which increase in size until they meet and coalesce into an *aethalium*, i.e. a rounded mass of confluent sporangia. By this coalescence, which occurs while the plasm is in a very fluid condition, air in spaces between the rising forms becomes entrapped; and this leads to the production of a pseudo-capillitium consisting of branching and anastomosing tubular air-passages with expansions at the axils, and numerous free, distended ends. Secretions from the plasm are discharged into these air-passages, and these deposit a very delicate membranous lining characterised by many wrinkles, which are afterwards, no doubt, accentuated by shrinkage in drying.

In the well-known genus *Stemonitis* the stalk is continued upwards as a columella nearly to the apex of the tall sporangium, and from this central columella, throughout its entire length, the capillitium branches in all directions, combining into a loose network, and becoming finer towards the periphery, until the ultimate branches unite in forming a delicate surface net. The outside of the net is covered with a frail membrane which constitutes the ephemeral sporangium wall; and after this has broken away, the spores escape through the meshes.

It is interesting to compare the surface-nets of *Stemonitis* with sporangial features of *Cribraria* and *Dictydium.* In these two genera the cavity is entirely filled with spores; and it is usually said there is no capillitium, because there are no threads in the interior. The sporangium walls, however, although more or less firm at the base, are for the most part membranous and evanescent; and here again the breaking away of the membrane reveals a surface-net with meshes which liberate the spores. As these nets are continuous with basal structures, instead of springing from a central columella, as in *Stemonitis*, they have hitherto been regarded as persistent remains of the sporangium walls; but there is little doubt that in origin and composition they are capillitial formations, as truly as the surface nets of *Stemonitis.*

The variations thus briefly described are only a few out of many, but for our present purpose the examples given are sufficient.* Biological interest in Mycetozoa is solely concerned

* For a complete set of illustrations see Lister's *Monograph of the Mycetozoa*, 2nd edition, revised, 1911. The plates in this work give in each instance a figure of the capillitium as well as of the sporangial forms.

with vital phenomena; and when the spores have been scattered, the sporangial remains, including the capillitia, are derelict and worthless. In fact, from first to last, the capillitial threads, notwithstanding their variety and often elaborate details, are sterile things, of only secondary importance, and of little biological significance. Still, they are direct products of the living organism; and the smallest thread which falls from the loom of life may convey at least a hint of the texture of the living fabric which is being so mysteriously woven on the frame of the universe.

Note.—Previous papers on the Mycetozoa, by the same author, were published in the *Journal of the Quekett Microscopical Club*, issued November 1906, November 1908, November 1910, November 1914, November 1915, April 1916, and November 1916. The present article concludes the series.

THE USE OF AMYLIC ALCOHOL AND SANDARAC IN MICROSCOPY.

By T. E. Wallis, B.Sc. (Lond.), F.I.C.

(*Read December* 10*th*, 1918.)

The object of the present communication is to direct the attention of microscopists to the use of amylic alcohol as a reagent, and to the value of sandarac, also known as gum juniper, as a mountant. By the aid of amylic alcohol the author has been able to prepare a sandarac medium that has a comparatively low refractive index, and which may be used in many instances where glycerine jelly is now employed and enables one to obtain permanent preparations of objects which either become shrunken or are rendered too transparent by the use of benzol- or xylol-balsam.

Sandarac is a resin imported from North-West Africa, and obtained by incision from the stem of *Callitris quadrivalvis* Ventenat, N.O. Coniferae. It consists of small cylindrical or stalactitic tears from 5 to 15 mm. long; it has a pale-yellow colour, and is hard and brittle. The refractive index is a little less than that of the dried resin of Canada balsam and is equal to that of oil of cloves. It is easily soluble in ordinary alcohol, amylic alcohol, ether and, by the aid of heat, in fixed oils; it is only partially soluble in benzol, petroleum spirit, chloroform and turpentine.

The very pale colour of sandarac has led to attempts to utilise this resin as a mountant, a solution in ordinary alcohol having been recommended for the purpose (**1**). Such a solution leaves a powdery, fractured film of resin after evaporation of the solvent and is quite useless for microscopical work. There are also some sandarac media, which are prepared according to unpublished formulae and of a complex nature (**2**); they are said to be very serviceable (**3**).

The amylic alcohol of the British Pharmacopoeia is a purified fusel oil, distilling between 125° C. and 143° C. It is a mixture of amyl and iso-amyl alcohols with small quantities of other alcohols. This alcohol is less volatile and more viscous than ordinary ethyl-alcohol; it is only slightly soluble in water (about 1 in 40) and is an excellent solvent for volatile and fixed oils, resins and phenolic substances. From a microscopist's point of view amylic alcohol possesses most of the useful properties of benzol and xylol and in addition those of ordinary alcohol, some, such as miscibility with water, in a less degree and others, such as its solvent powers for fats and fixed oils, in a more marked degree. It is also miscible in all proportions with ordinary ethyl-alcohol and glacial acetic acid.

These facts suggest the possibility of using amylic alcohol for the preparation of clearing and dehydrating reagents, and as a solvent for Canada balsam and other resins in the preparation of mounting media.

When a solution of sandarac in amylic alcohol is allowed to evaporate, it leaves a hard, colourless, varnish-like film of resin which shows no tendency to crack or split away from the slide. This result showed that such a solution of sandarac should prove suitable for mounting microscopic objects. Subsequent experiments have fully confirmed this expectation.

The brittleness of sandarac resin may be still further counteracted, and the refractive index slightly reduced by the addition of a small proportion of fixed oil. Castor oil is especially suitable for this purpose, since it is freely soluble in amyl-alcohol and will completely dissolve sandarac resin when the two are heated together; its refractive index varies from 1·479 to 1·4805 at 15° C.

The following formula was finally adopted:

AMYL-SANDARAC

Castor oil . . .	4 c.c.	or	3 grm.
Sandarac . . .	32 grm.	,,	25 ,,
Amylical cohol . .	64 c.c.	,,	50 c.c.

Add the castor oil and the amylic alcohol to the sandarac in a corked wide-mouthed bottle. Allow to stand, with occasional shaking, until solution is complete. Filter through cotton wool.

As some workers may prefer to weigh the castor oil rather than measure it, a suitable alternative formula is given. For this mounting medium I have proposed the name amyl-sandarac.

The refractive index of the medium is a little difficult to determine because the amylic alcohol is the ingredient of lowest index, viz. 1·40, and is constantly evaporating whilst the medium is drying. The result is that the mountant in a finished preparation has an index depending upon the extent to which the alcohol has disappeared. The final condition of the medium will also vary according as the mount is made in the ordinary way or by the exposure method. In the former case experiment shows that the refractive index is about 1·45 while in the latter it is about 1·48.

The amylic alcohol is the constituent that is mainly responsible for the low refractive index, and if one substitutes, in the above formula, the resin of Canada balsam for sandarac one obtains a very similar medium—amyl-balsam—which can be used in the same way as the amyl-sandarac.

For various reasons the sandarac medium is preferable. In the first place, sandarac does not require any preliminary heating to remove non-resinous volatile constituents as is the case with Canada balsam, but is suitable for use in its original state. Secondly, the pale colour of sandarac is so marked that the medium appears quite colourless in the case of all ordinary mounts, and in the case of thick mounts, such as are necessary for whole insects and other bulky objects, the mountant possesses only a very pale lemon-yellow tint in place of the deep golden yellow of similar balsam mounts.*

* The effect of amyl-sandarac and amyl-balsam in rendering visible certain delicate structures owing to the low refractive index of these media was well shown in photographs taken from preparations of crystals of calcium carbonate obtained as a scale on evaporating a well-water. The delicate rosette crystals so apparently abundant in the amyl-sandarac preparation were hardly visible and, if not known to be present, would probably be overlooked in the benzol-balsam mount.

A good clearing and dehydrating agent for use with amyl-sandarac is made by dissolving one part by weight of phenol crystals in one part by volume of amylic alcohol, a liquid which may be conveniently named amyl-phenol. This substance is superior to clove oil and turpentine because it does not cause the undesirable hardening and shrinking effects which these oils produce. It is also preferable to liquefied phenol (liquid carbolic acid) because it contains no water and will abstract small amounts of water from objects immersed in it. From this reagent preparations may be transferred directly to the mountant.

To mount a whole spider or insect without pressure in sandarac one proceeds as follows: Steep the specimen in 10 per cent. caustic soda or potash until thoroughly relaxed, transfer to water, glacial acetic acid, amylic alcohol and amyl-phenol in succession, allowing time in each case for a thorough penetration by the liquid used. The object is next placed underside uppermost upon a clean cover-glass, to which three clear-glass beads of a suitable size have been previously fixed by some of the mountant. The legs and other appendages are arranged, if necessary, with a needle or brush, the object is covered with amyl-sandarac and allowed to stand freely exposed to the air, but carefully protected from dust. During these operations the cover-glass is best supported on a cork whose smaller end is a little less in diameter than the cover-glass. As the solvent evaporates, further quantities of the mountant are added until the layer of resin is sufficient to completely embed the object. A drop of amyl-sandarac is now placed in the centre of a microscope slide, and a second drop on the resin covering the object; the cover-glass with the object is then carefully picked up and inverted upon the slide. As the mountant shrinks under the cover-glass, it is replaced by fresh quantities allowed to flow underneath by capillary attraction. A very satisfactory preparation may be thus obtained.

It will be noticed that I have recommended supporting the cover-glass during the evaporation of the solvent upon a cork, which should be from 4 to 6 mm. less in diameter than the cover-glass. It is not possible to place the cover-glass on a glass slide as is generally recommended (**4**) for benzol- or xylol-balsam, because amylic alcohol shows the property of spreading rapidly over a surface and would creep over the edge of the cover-glass on to the slide; this difficulty is avoided by the use of a cork.

Pseudo-scorpions and mites may be very simply prepared for mounting by taking material, either fresh or preserved in alcohol, and macerating in chloral-phenol until quite transparent. (Chloral-phenol is the liquid obtained by mixing together equal weights of phenol crystals and chloral hydrate and warming gently until liquefied.) The specimens are then removed on the tip of a fine sable-hair brush to amyl-phenol, and finally to a microscope slide and covered by amyl-sandarac and a cover-glass. Although it is not always desirable, this method enables one to avoid preliminary treatment with potash or soda, when one wishes to do so. In any case, the resulting preparations are really permanent in character and therefore preferable to those made by the use of glycerine jelly, and the low refractive index of the amyl-sandarac makes clearly visible the hairs and the outlines of the chitinous plates, features which are almost obliterated by the use of benzol-balsam.

By a similar treatment one can make good permanent mounts of liverworts and mosses, which are first thoroughly relaxed by immersion in boiling water, excess of moisture being removed by blotting-paper. In this case it is often desirable, after soaking in chloral-phenol, to boil the liquid gently so as to expel the air thoroughly. Transfer to amyl-phenol and mount in amyl-sandarac. The preliminary treatment with chloral-phenol is not always necessary, since amyl-phenol alone will render the plants quite transparent and dehydrated, if they are soaked in it for a sufficiently long period.

These instructions for mounting should not be followed too rigidly. It will be found in some cases that steps may be safely and advantageously omitted, while in other circumstances additional precautions must be taken.

For example, it is generally necessary to subject insects, spiders, etc., to a preliminary treatment with caustic alkali; but in the case of a small beetle which had died and become quite dry, I found that an excellent mount was obtained without the use of alkali, the preparation being made by steeping and boiling the insect in chloral-phenol till clear and free from air, transferring to amyl-phenol and then mounting in amyl-sandarac.

References.

1. Lavdowsky. Through Lee's *Microtomist's Vade-Mecum*, 7th edit., p. 248.
2. Gilson. *La Cellule*, 1906, through *Journ. Roy. Micr. Soc.*, 1907, p. 501.
3. Lee. *Microtomist's Vade-Mecum*, 7th edit., p. 247.
4. Cole, A. C. *Methods of Microscopical Research*, p. 134.

A NEW FORM OF POLARISER.

By Edward M. Nelson, F.R.M.S.

(*Read January 14th,* 1919.)

Figure in Text.

It is now no longer possible to add a large Nicol to one's box of microscopic apparatus, because of the greatly increased price of large pieces of calcite. A large Nicol is required when the back lens of a low-power condenser has to be filled with light. With the Nicols that can now be obtained, only a condenser with a small back lens can be filled, and if that condenser has any useful aperture it follows that it must be of high power. A condenser suitable for the bulk of microscopical polariscope work, such as rock sections, rings or brushes in quartz, etc., would be a wide-angled 1/2 in., which of course has a large back lens, which the modern 3/8 in. polariser would not nearly fill. It is obvious, therefore, that some other kind of polariser is required. Experiments have been made with several. First, a tourmaline. This is satisfactory. but the colour is a fatal objection, also it is expensive. Secondly, black glass. This entails much loss of light, it is a poor polariser, and not at all satisfactory. Thirdly, a pile of plates, which is excellent, and practically as good as a Nicol. Therefore the pile of plates has been selected for this new instrument. I have already shown the value of a pile of plates set in the cell in place of the concave mirror. This plan answers perfectly when one is able to set, in a few seconds, the mirror and source of light at the proper polarising angle. It was also shown how a card cut at twice the polarising angle would be of assistance. But there are some who have much difficulty in putting the mirror in the proper position; when they do succeed, it is either by chance or after the expenditure of half an hour's labour. It was therefore necessary to see that this new apparatus should be fool proof. A glance at the figure, which is so simple that it hardly requires explanation, will show that it is so, for the emergent beam is parallel to the immergent one, and the box is in a line with the beam. It is as easy to place this box between the lamp and the microscope mirror as it is to place a common bull's-eye.

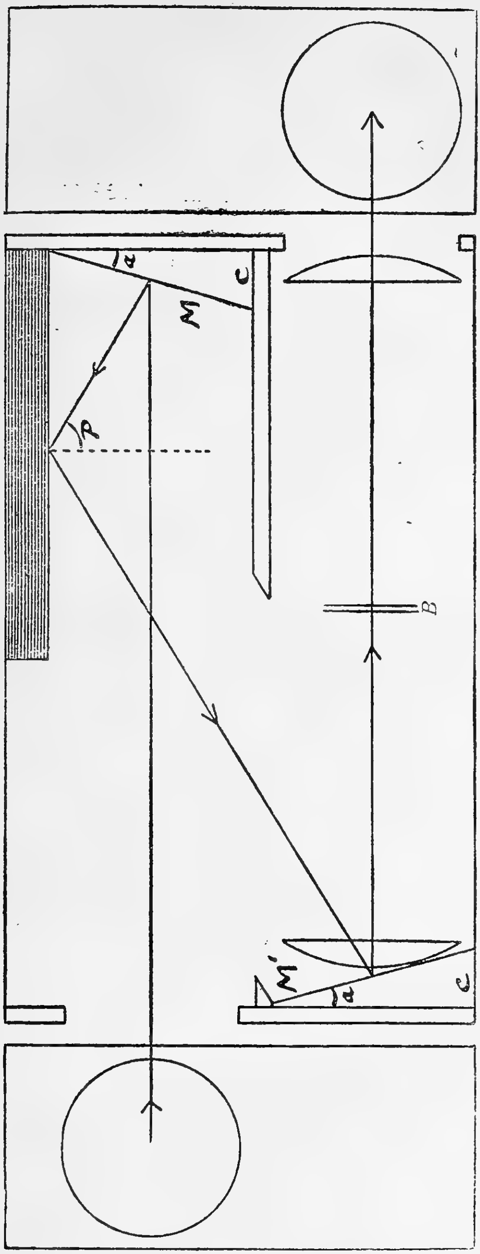
In the figure the light is seen entering the circular hole in the left-hand end of the box; it falls on the mirror M, is reflected on to the pile of plates G, and thence to the mirror M^1, by which it is reflected out of the hole in the right-hand end of the box.

The diameter of the hole is the diameter of the required beam; d, the breadth of the mirrors MM^1, should be somewhat (say 1/4 or 3/8 in.) greater than that of the hole. P is the polarising angle; a the inclination of the mirrors MM^1. MM^1 the length of the mirrors, and G the length of the glass plates. C is the base of the mirror triangle, shown in the figure. Then

$$a = \frac{90° - P}{2}; \quad M = d\sec a; \quad G = d\sec P; \quad C = d\tan a.$$

The following are the inside measurements of the box: Length $= 2\ G - c$; width $= d$; depth $= 2\ d + 1/2$ in. For flint glass $\mu = 1{\cdot}62$; $P = 58°\ 20'$; $a = 15°\ 50'$; $G = 1{\cdot}904d$; $M = 1{\cdot}039d$; $c = 0{\cdot}284d$. Note, extra-thin slip glass is a suitable glass for a pile of plates. The glasses should be put into strong sulphuric acid for a couple of hours, then washed in many changes of water, then placed in methylated spirit, then dipped in absolute alcohol and wiped clean. When treated in this manner they will keep clean for a long time, otherwise they will soon get steamy and sticky, and require frequent cleaning. All microscope slides and cover-glasses should be cleansed in this manner.

No reference has yet been made to the two plano-convex lenses in the lower compartment. The difference between an instrument of this form and a Nicol will be seen when they are rotated. In this instrument the emergent beam would describe a circle of some inches diameter round the immergent beam, while the displacement caused by the rotation of a Nicol is slight, and can be adjusted by the substage centring screws. Dr. Sylvanus Thompson, who has done so much for science by his improvements of the Nicol, devised the following method to meet this case. He said that if a 1/4 wave-length plate was fixed with its axis at an angle of 45°, and if a similar plate



α
c
M
p
B
M'
α
c

placed close to it was capable of rotation, then the rotation of that plate would give the same effect as the rotation of a Nicol. Now as it is difficult to cut 1/4 wave-length plates of a large size, the following is a means of reducing the beam so that it can pass through a disc of small diameter, and then be parallelised to full size upon emergence. *B* are the 1/4 wave-length plates. Please note particularly that for all ordinary microscopical work the rotation of the polariser is not essential, therefore the two lenses and the 1/4 wave-plates may be omitted. A useful size for a microscope would be: hole 1·5 in. diameter; $d = 1{\cdot}75$ in.; $MM^1 = 1{\cdot}82$ in.; $c = 0{\cdot}5$ in.; $G = 3{\cdot}33$ in. (which may with advantage be increased to 3·5 in.); length of box 6·5 in.; width 1·75 in.; depth 4·0 in. The box should have a slide at *G* so that the plates and mirrors can be readily got at for cleaning. The above are inside measurements. Polarisation by means of transmitted light through a pile of plates has been tried. The results were exceedingly poor, in fact quite worthless when compared to those obtained by reflection, which, when 20 or 24 plates were used, were practically as good as by a Nicol.

The percentage of polarised light given by any number of plates can be determined by the following formula: $x = 1{\cdot}2135 + 2{\cdot}2075y + 3{\cdot}5245y^2 - 1{\cdot}9237y^3 + 0{\cdot}2702y^4$; $y = \sqrt[3]{n}$; $P = x^2$; n is the number of plates, and P the percentage of polarised light. Example, let $n = 8$, then $y = 2$, $x = 8{\cdot}66$ and $P = 75{\cdot}0$. So we see that with 8 plates three-quarters of the incident light will be polarised by reflection at the proper angle.

THE PRESIDENT'S ADDRESS.

SOME CASES OF ADAPTATION AMONG PLANTS.

By A. B. Rendle, M.A., D.Sc., F.R.S.

(*Delivered February* 11*th*, 1919.)

One of the most obvious characteristics of plants is the remarkable adaptation which they show to their environment. It is scarcely necessary to recall instances, but I may remind you that though these adaptations are sometimes so striking as to impress the layman, as, for instance, in the insectivorous plants which formed the subject of an address at our last meeting, yet the botanist is aware that every plant, one might almost say every plant-organ, represents a finely adjusted correlation with its surroundings; otherwise it would cease to exist. But again it must be obvious that other factors than present environment govern the form and structure of plants, otherwise all the plants growing in one and the same locality would show the same type of adaptation. On the contrary, different species of plants show widely differing responses to the stimulus of the same environment. Closely allied species growing close together may show striking differences, to the observing eye, in external form. A familiar example is found in the two buttercups which you may find in the same meadow, the one, *Ranunculus acris*, with straight rootstock and spreading sepals, the other, *R. bulbosus*, with stem swollen at the base and reflexed sepals. Here are two closely allied species which, on any theory of evolution, have sprung from the same ancestral form at no very distant period, and are now growing side by side. The explanation of these differences must be sought in the history of the two species since their separation from the parent stock. But I do not propose to deal with theories of evolution or the part which adaptation to environment may have played in that connection. I wish merely to refer to some cases which indicate what we may term the limitations of adaptation, or point out the danger of assuming that form and structure as we now see them are *ad hoc* adaptations to existing conditions.

The sundew (Drosera), living, as we know it in this country, in a substratum almost devoid of nitrogenous food-stuffs, the sponge-like sphagnum-bog, has developed an efficient means for obtaining its nitrogenous food from the bodies of insects, which it first attracts, then captures and finally digests. In the form and structure of the leaf-tentacle, you, as microscopists, will appreciate the beauty and apparent perfection of adjustment of the details of structure to the end in view.

The genus Drosera, represented in Britain by three species, is a large and widely distributed one. There are about ninety known species; the British are widely distributed in the northern hemisphere, others are in South-East Asia, South Africa and North and South America; but the richest area is extra-tropical Australasia, especially West Australia in which occur more than half the known species. The type of habit of our native species, a rosette of basal leaves with a central stem bearing a few flowers, is also widespread. But in South-Western Australia a remarkable secondary adaptation has arisen. A number of species occur with long thread-like stems which climb over low-growing shrubs or bushes, attaching themselves to leaves or twigs by means of the marginal tentacles. You will notice that the climbing leaves are distinguished by their longer stalks; they arise at intervals on the elongating stem, which bears also numerous leaves which still retain their purely insectivorous habit. The specimen shown I collected in a gully on Mt. Lofty, near Adelaide in South Australia. In the same gully were growing large patches of a species with a leaf-rosette recalling our *D. rotundifolia* in habit, but with larger leaves and white flowers as big as a buttercup. The South-West Australian species show a great variety in flower-colour, yellow, white, pink, scarlet, crimson or purple, and the plants vary in size from minute forms with leaf-rosettes scarcely more than one inch in diameter, and with flower-scapes little more than an inch high, to sturdy, erect, much-branched plants three feet high or to climbers reaching a length of five feet.

About two-thirds of the species of Drosera are epigeal—that is to say, do not persist by means of a permanent underground structure. These are sometimes short-lived, as in *D. indica*, a native of the tropical monsoon region which grows in a saturated soil and runs through its life-cycle from germination to seeding in one season. More often they are perennial, as in *D. rotundifolia*, and adapted to climates which show a marked periodicity. In this species the leaves of the rosette wither at the approach of winter, leaving a large central resting-bud on the surface of the bog-moss. During the winter this is buried by the growth of the surrounding moss; with the warmth of spring the bud starts growth again, the internodes develop and a vertical stem is formed which produces only a small leaf at each node until the surface of the moss is again reached, when it forms the familiar spreading leaf-rosette and develops an inflorescence from the axil of one of the leaves. By piling the moss round the plant during development of the rosette the action may be interrupted and the successive internodes will again lengthen until the surface of the moss is once more reached.

About one-third of the species belong to a subgenus which is practically limited to Australasia, and are adapted mainly to life under conditions where a damp winter alternates with a dry season. At the approach of the dry season the plant dies down, and persists during the drought as a bulb which is buried deeply in the soil; the plant is what is termed geophilous. The portion of the stem below ground bears leaf-structures with a much-reduced blade which function as rhizoids. When the surface of the soil is reached a leaf-rosette may be formed, or the stem may continue to elongate, in which case the lower leaves are reduced to small scales with no blade. In the axil of the upper scale-leaves is formed a pair of functional leaves, while higher on the stem the subtending leaf itself develops a blade. The stem may be comparatively short and end in an inflorescence, or be more or less elongated and show in very varying degrees the climbing habit. The climbing organ is the leaf of the first order, which has a much elongated stalk. After the terminal gland of a tentacle has become attached to the supporting object its stalk becomes bent to make a spring-like attachment. The bulb consists of very closely united leaves the tips of which only are free: it is renewed each year by a lateral bud developed at the base of the stem which grows down into the older bulb and finally replaces it, except for the outermost scales which form a protecting coat. When the plant has died down the portion beneath the ground does not completely perish, but its dead remains cling round the new stem, forming a kind of veil consisting of long strips of tissue the cell-walls of which have numerous oblique pores. The whole forms a capillary system which holds moisture for the supply of the rhizoids of the new stem, and thus acts in a way similar to that of the surrounding sphagnum to our native sundews.

I spoke of this climbing habit as a secondary adaptation, but it is really a tertiary. The primary adaptation of the green leaf is to form a flat surface for exposure to the air and sunlight. Secondary adaptations are not infrequent, especially in connection with the climbing and insect-eating habits; here in these Australian Droseras a third adaptation is superposed on the other two. In the genus Nepenthes, the pitcher-plants of tropical Asia, these three adaptations of the leaf are superposed along the leaf-axis—first the assimilating portion, then a tendril-like portion for climbing and at the extreme tip the elaborate insect-trap. It is interesting to note that there is in Australia a small genus of pitcher-plants, Cephalotus, in which the pitchers are distinct from the foliage-leaves and are associated with these at the ground-level. The climbing Nepenthes is eminently adapted to its habitat; the plants climb on the trees or bushes growing by the sides of streams where insects are plentiful, the pitchers being held invitingly into the air; and we may assume that the Australian climbing Droseras have during some period of their history found that their survival in the struggle for existence was rendered possible only by leaving the earth-floor and climbing over surrounding herbage or shrubs to exploit the upper regions of the air for their necessary nitrogenous food.

Now may I refer to a very different case, in which form, structure and analogy with a large series of allied forms suggest an adaptation which has, however, ceased to exist. You are familiar with our British orchids and the means by which they ensure pollination by the agency of insects. But our native Bee-orchis, while retaining a striking form and coloration, has lapsed into the habit of self-pollination, the pollinia merely falling from the anther-case on to the stigma beneath. Similar instances have been noted, but they are rare in this large and widespread family, containing more than 6,000 species distributed among 450 genera, and occurring almost everywhere where conditions render possible the existence of flowering plants except in the coldest regions. The Orchids supply one of the best examples of remarkable variety of detail in adaptation of a type of flower, formed on a comparatively simple plan, to the effecting of pollination by means of insects. In this case the reason for the adaptation is obvious; we know but little as to the details of pollination of exotic species of orchids, but may assume that the amazing variety of form and colour is associated with a correlated variety in the type of visiting insect.

But there is another great and even more widely spread family in which the form of the flower, coupled with the form of the inflorescence, shows a variety comparable with that of the Orchid. I mean the grasses. What has been the determining factor here? Grasses are wind-pollinated, and the breeze is a blind agent. The pendulous anthers and protruding stigmas are eminently adapted for this purpose, but there is an infinite variety in the form and detailed structure of the outer covering or "glumes" which can have no relation to wind-pollination. In some cases the distribution of the ripe seed is aided by the form of the glume or its appendages, as, for instance, by the presence of awns or stiff or silky hairs; but this factor will not explain the great majority of the variations in details of structure. In many cases the parts concerned have fallen before the grain is dispersed, or have lost so much of their characteristic form that the species cannot be satisfactorily determined. Are we dealing here with merely indiscriminate variation? The discrimination of species in some genera is notoriously difficult, as for instance in the Poas and Fescues, and the explanation may be that there is nothing to check variation. Indiscriminate variation would be checked at once in a type of flower so nicely adjusted to pollination by a particular insect as are many orchids—it would be suicidal. But in a wind-pollinated flower a wide variation might have no effect on the transmission of pollen.

An interesting case of secondary adaptation is found in the so-called viviparous grasses, which occur especially in high latitudes and upon high mountains where ripening of fruit is often uncertain. Entire spikelets or single flowers, with floral glume and pale, are transformed into small-leaved shoots which bear at the base the beginnings of roots. These miniature shoots fall from their axis and root in the ground. *Poa stricta* is known only in this form, while *P. alpina* and *Festuca ovina* are sexual, that is, bear ordinary fertile flowers, in lower countries, but frequently depend on the asexual or viviparous form in high mountains or in the north.

Thus while in numerous cases adaptation is obvious even when, so to speak, grafted on a primary or even secondary adaptation, there are large series of forms where we are unable to explain form and structure by any known relationship with environment. Are we dealing here with purely indiscriminate variation or do we merely proclaim our ignorance? I need only mention the diatoms to suggest an instance of extreme variation in detailed structure for which at present we can find no explanation in adaptation to environment. The great variety in form and sculpturing of pollen-grains and other spores will supply further instances. May I refer to one other case in closing; namely the colours of the larger fungi which run through almost as striking a gamut as the colours of flowers, but which cannot be explained in a similar way as attractive or otherwise to members of the animal kingdom. We have hitherto regarded this as an example of so-called indiscriminate variation, but recent work indicates that the explanation may be a physiological one associated with nutrition.

HYDRACARINA: THE GENUS OXUS *KRAMER.*

By Charles D. Soar, F.L.S., F.R.M.S.

(*Read March* 11*th*, 1919.)

Plate 1.

1877. Oxus P. Kramer. *Arch. Naturg.*, vol. xliii. page 240.
1880. Pseudomarica Neuman. *Svenska Ak. Handl.* New series, vol. xvii. No. 3, page 70.
1901. Pseudoxus Sig Thor. *Norges Hydrach*, vol. i. page 18.

This is one of the four genera of the sub-family Lebertiinae. It has a number of species, three of which have been recorded for the Britannic area: *O. plantaris* Sig Thor, *O. strigatus* Müll. and *O. ovalis* Müll. The type species of this genus *O. quadriparus* Pier. (= *oblongus* Kramer) has not been found in the Britannic area, so I propose to use *O. plantaris* Sig Thor in its place. It is by far the largest species of the three, and I was fortunate in having quite a number of specimens sent to me alive by Mr. G. T. Harris, of Sidmouth, who washed them out of some sphagnum found in a bog on Dartmoor in 1918. In the original descriptions by Sig Thor and in that of Mr. Halbert only the female is mentioned; but in the collection of living specimens sent me by Mr. Harris besides females there were several males and one nymph included, and it is from these the description is taken.

The generic characters of Oxus are: Body an elongated oval, dorso-ventrally compressed; skin soft, granulated or striated; dorsal surface without band or furrow as in Frontipoda and Gnaphiscus. Epimera fused into one piece and covering the greater part of the ventral surface. Legs close together on anterior part of body, as in Frontipoda; fourth pair without claws. Genital area partly enclosed by epimeral plate. Male and female very much alike.

Oxus plantaris Sig Thor.

Pl. 1, figs. 1–13.

1900. *Oxus plantaris* Sig Thor. Eine Neue Oxus-art, *Nyt Mag. Natur.*, xxxviii. pages 277–279, plate xi. figs. 10–12.

1911. *Oxus plantaris* Halbert. Clare Island Survey, part 39*i*, page 25, plate ii. fig. 21, *a–c. Proc. Roy. Irish Acad.*, vol. xxxi.

Female.—Length about 1·26 mm., breadth 0·80 mm., height 0·75 mm. Neither of the writers above mentioned gives the measurement of this mite, but each says it resembles *O. ovalis*; with us *O. ovalis* is much smaller. The shape is a long oval; viewed from the dorsal surface it is much like Frontipoda or Gnaphiscus, but from the lateral view it will be seen to be very much less arched (Pl. 1, fig. 2). The colour in nearly all Mr. Harris's specimens was a bright orange with black velvety-looking markings on the dorsal surface. The legs were also of the same bright orange colour. There is a patch of light orange colour in the centre of the dorsum. Mr. Halbert gives the colour of his female as reddish-brown with slate-coloured appendages. The coloration of the water-mites we know from experience does not count for much, and there is no doubt it is regulated to a large extent by the environment. There was one female in the collection inclined to blue in the legs and another one (a male) with pale bluish legs, orange-coloured at the distal end of each segment, but they were very faintly coloured and had nothing of the brilliancy found in the other specimens. The skin of the body is soft and striated; the dorsal surface has a number of dermal glands and hair-pores, but these are hardly noticeable during life on account of the brilliant colouring. The epimera are thick and the surface is granulated. The eyes black and placed well forward on the body about 0·20 mm. apart. The ventral surface is more than half covered by the epimera (Pl. 1, fig. 1). At the apex of the first pair of epimera there are two strong curved spines (Pl. 1, fig. 3) which form one of the characteristics of this species. The capitulum is small and does not extend as far forward as the apex of the epimera. The palps are about 0·23 mm. long (Pl. 1, fig. 4). The second segment has two short spines on the extensor margin and two long ones at the distal end, and one not so long placed a little way down on the outside edge at distal end. The third segment has also two long spines placed near the middle of the extensor margin. The fourth segment is the longest, and has two or three fine hairs on the extensor margin.

The genital area is placed in a shallow bay formed on the posterior margin of the epimeral plate. The anterior edge of the genital plates nearly touches the bottom of the bay, but at the posterior end of the bay the sides are wide apart; the depth of the bay is about three-fourths the length of the genital plates. The genital area is composed of two movable plates which expose or partly cover three acetabula on each side of the genital fissure. Another characteristic of this species is the shape of these genital discs, which are fusiform or spindle-shaped. Pl. 1, fig. 7 is one drawn to show how it appears at the side of the fissure. In other species of this genus the acetabula are rounded at each end, not spindle-shaped.

The legs are very like those found in Frontipoda and Gnaphiscus, and require no special description, but all are figured on Pl. 1, figs. 9–12.

Male.—The male, which does not appear to have been found by either Sig Thor or Halbert, is very like the female. Not much description is necessary; it is as usual a little smaller than the female, being about 1·0 mm. in length. The genital area is smaller, not so wide, and placed closer to the posterior margin (Pl. 1, fig. 6). The discs or acetabula are of the same shape as in the female. The male genital organs can be seen through the chitin of the epimera in mounted specimens, but not sufficient detail can be made out for the purpose of making a satisfactory drawing. The two strong spines at the apex of the first pair of epimera are similar to those found in the female.

Nymph.—The nymph is about 0·55 mm. long and has the same outline as the adult. It is also of the same orange colour, but less brilliant. The provisional genital area is formed of *four* acetabula protected on each side by a chitinous ridge Pl. 1, fig. 8). The legs have fewer hairs. Only one nymph has been found, which is probably the nymph of the male. It will no doubt be found that the nymphs of the male and female are quite distinct, as was the case in the genus Frontipoda.

The larvae and life-history are unknown.

Found at Cartron mountains in a bog pool by S. W. Kemp, recorded by Halbert; and near Lydford, Devon, in a bog pool by G. T. Harris.

The figures have all been drawn from specimens sent by G. T. Harris, from Dartmoor.

Description of Figures, Plate 1.

Fig. 1. Ventral surface of ♀.
,, 2. Lateral view showing height (diagrammatic).
,, 3. Distal end of 1st epimeron.
,, 4. Palp of ♀.
,, 5. Genital area, ♀.
,, 6. Genital area, ♂.
,, 7. One of the acetabula shown in outline.
,, 8. Provisional genital area (nymph).
,, 9–12. The four legs from one side of female showing arrangement of spines and swimming hairs.
,, 13. Ventral surface (nymph).

Oxus ovalis (Müll.) Koenike.

Pl. 1, figs. 14–15.

1776. *Hydrachna ovalis* Müller. *Zool. Dan. Prodr.*, page 190, no. 2264.

1781. *Hydrachna ovalis* Müller. *Hydrach.*, page 53, pl. 10, figs. 3–4.

1898. *Oxus ovalis* Koenike. *Zool. Anz.*, vol. xxi. page 71.

1899–1900. *Oxus strigatus* Soar. *Sci. Gossip*, N.S., vol. vi. page 177, figs. 1–3.

Female.—This mite is smaller than the preceding species, being about 1·0 mm. long, and about 0·55 mm. broad. Similar in shape to *O. plantaris*, a long oval less in width in front than at the posterior end. Colour a reddish yellow with dark-brown markings on dorsal surface. Epimera and appendages a slaty blue.

The epimera are carried much farther towards the posterior margin on the ventral surface than is the case in *O. plantaris*. The epimeral plate is about 0·70 mm. long. The genital area is about 0·18 mm. long, with the acetabula rounded at each end.

not fusiform as in *O. plantaris*. The bay of the epimera is wide at the posterior end (Pl. 1, fig. 14). The anus is placed about one-fifth the length of the genital plate behind the genital fissure, the two anal glands being wide apart and placed well behind the anus, not in a line.

In place of the two strong spines at the apex of the first pair of epimera in *O. plantaris* (Pl. 1, fig. 3) two broad blunt teeth are found (Pl. 1, fig. 15) presenting a very different appearance.

Male.—The male is about 0·85 mm. long. The epimeral plate covers more of the ventral surface than it does in the female. The posterior end of the genital bay is not so broad and the genital area only measures about 0·14 mm. in length.

Lincolnshire, by D. George. Norfolk Broads, Burnham Beeches, Tunbridge Wells and Mill Hill.

DESCRIPTION OF FIGURES, PLATE 1.

Fig. 14. Ventral surface of female showing genital area and position of anus and anal glands.

,, 15. End of 1st pair of epimera showing the blunt tooth-like processes.

Oxus strigatus (Müll.) Piersig.

Pl. 1, figs. 16–18.

1776. *Hydrachna strigatus* Müller. *Zool. Dan. Prodr.*, page 191, no. 2279.

1781. *Hydrachna strigatus* Müller. *Hydrach.*, page 71, tab. 10, figs. 1–2.

1835. *Marica strigatus* Koch. *C. M. A.*, fasc. 5, f. 23.

1880. *Pseudomarica formosa* Neuman. *Svenska Ak. Handl.*, N.S., vol. xvii. no. 3, page 71, tab. 5, fig. 2.

1892. *Frontipoda strigatus* Koenike. *Zool. Anz.*, vol. xv. page 263.

1897. *Oxus strigatus* Piersig. *S. B. Ges. Leipzig*, vol. xxii.–xxiii. page 86.

Female.—This mite is the smallest of the three species, being about 0·80 mm. long. Very like *O. ovalis*, only narrower. Colour a yellowish green with dark-brown markings on dorsal surface;

the malpighian vessel being light yellow. The epimera and appendages are a greenish blue, in some specimens quite blue. The eyes are about 0·1 mm. apart, of a bright-red colour.

The genital area is about 0·13 mm. long, about half of which lies within the bay formed by the posterior margin of the epimeral plate. This bay is not so wide on the outside margin as in the preceding species, the two sides being nearly parallel (Pl. 1, fig. 16). The anterior part of the epimera does not project beyond the frontal margin. One striking point which differentiates this species from *O. ovalis* is that the anus is placed in the line connecting the two anal glands.

Male.—The male is about 0·65 mm. long, and less in width than the female in proportion to its length. The genital plates project about one-third beyond the end of the epimera, of which the bay in the posterior margin is about 0·1 mm. deep, and as in the female the sides are nearly parallel.

Cumberland, Oban, Surrey.

Description of Figures, Plate 1.

Fig. 16. Ventral surface, ♀.

,, 17. One of the acetabula in outline showing the rounded ends. Compare this with fig. 7 (*O. plantaris*).

,, 18. Palp of female, lateral view of right palp.

AMPHORA INFLEXA, A RARE BRITISH DIATOM.

By George West
(*University College, Dundee*).

(*Read March 11th*, 1919.)

Plate 2.

In the *English Mechanic*, February 5th, 1915, p. 37, appeared an illustrated query from "D. G." respecting a marine diatom. In the next number, p. 51, "N. E. B." remarks upon this specimen, doubtfully regarding it as a variety of *Amphora quadricostata*, and on p. 59 two other writers suggest names. On p. 78 "D. G." supplemented his query with further particulars, and by a printer's error has been made to say—"It is a Bristol diatom, found by me in Carmarthen Bay." For Bristol read British. More recently a well-known Belfast diatomophile was appealed to, and he referred the finder to the present writer, who, owing to war pressure, failed to see the above-mentioned correspondence until his attention was directed to it recently by the gallant and courteous "D. G." *

The diatom in question is the **Amphora inflexa** of H. L. Smith, described in *The Lens*, 1873, p. 78, Pl. II. fig. 16. It had previously been named *Amphipleura inflexa* by De Brébisson, who found it at Calvados in Normandy on maritime rocks, and described it in the *Species Algarum* of Kützing, 1849, p. 88. These names were mentioned by me when dealing with Amphi-

* The author is permitted to state that "N. E. B." referred to above is N. E. Brown, A.L.S., late of the Herbarium, Kew, and "D. G." is Capt. David Griffiths, Southbourne, near Bournemouth.

pleura in the *English Mechanic*, November 3rd, 1916, p. 293. W. Smith in his *British Diatomaceae*, 1856, vol. ii. p. 90, calls it *Amphipleura inflexa*, as found by Mr. J. Ralfs, at Ilfracombe. In Pritchard's *Infusoria*, 1861, p. 783, Ralfs describes it under the same name, giving a poor illustration, Pl. IV. fig. 31. About 1868 a new genus was instituted for this diatom by Th. Eulenstein of Stuttgart when issuing it with his type-slides of diatoms. He called it *Okedenia inflexa* in honour of Mr. F. Okeden, a British engineer and diatomist, who wrote in the microscopical journals about 1855 to 1858. De Toni, in his *Sylloge Algarum*, II, I, p. 229 (1891), maintains Eulenstein's generic name, adding two other doubtful species. This diatom is mentioned, and illustrated by two poor figures in Van Heurck's *Treatise on the Diatomaceae*, English edition, 1896, p. 135; where by error it is placed under section Halamphora of Amphora, instead of under section Amblyamphora. That author, apparently, had never gathered specimens nor seen them living. Besides the two localities already mentioned it has also been found at Biarritz, South-West France, by Leuduger-Fortmorel, and, according to Cleve, from the estuary of the Tay, and the Adriatic. Cleve gives no authorities for his statement, but the Tay observation was probably by Mr. Richard Rattray, a working engineer and diatomist of Dundee. This naturalist must not be confounded with Mr. John Rattray who wrote the excellent monographs on Coscinodiscus, Aulacodiscus, Auliscus, etc., whose native place was Perth. "Dick" Rattray wrote very little, but was an assiduous collector and preparer of diatoms, who greatly assisted Adolf Schmidt, and whose name is frequently mentioned in the *Atlas der Diatomaceen-Kunde*.

Regarding the various names of the diatom in question the structure of the raphe is sufficient, alone, to distinguish it from any species of Amphipleura. From any Cymbella or Ceratoneis, both of which it more closely resembles, it differs in having a complex girdle, and from the latter genus also by the possession of a true, although very faint, raphe. From any of the foregoing genera it differs also in having the ventral side of the frustule slightly narrower than the dorsal side. It is no Epithemia, as one correspondent suggests, because, among other reasons, there are no transverse ribs alternating with delicate rows of punctae. It differs in appearance from the more usual outline of the 220 known forms of Amphora by the high proportion of its breadth-length ratio, which, however, is not a character of generic value. Being a true Amphora the establishment for its reception of the genus *Okedenia* is opposed to the laws of scientific nomenclature and cannot be maintained. It therefore follows that the latter name must be regarded as a synonym, and the excellent Mr. Okeden commemorated in some other way.

So far as I can glean, "D. G." is the first diatomist to have found this rare species on the coast of England or Wales since the time of Ralfs, or for more than sixty years. As this species has never been adequately described or figured, and as "D. G." has kindly supplied me with a sample of a fresh gathering which he has fortunately obtained, I readily comply with his request that I should describe and figure it.

Description.—Valve sub-linear, arcuate, a little flattened at the middle on the dorsal side, and often slightly tumid about the centre on the ventral side, from which it narrows almost imperceptibly towards the rounded, sub-capitate ends which are slightly recurved (fig. A). Length, 74 μ to 150 μ. Breadth at centre, 7μ to 9μ; near apices, 5μ to 7μ. Central nodule homogeneous, very narrow, elongate, slightly arcuate and placed one-third width of valve from ventral margin. From this nodule the very narrow indistinct raphe area is, on each side, arcuate, approaching the dorsal margin to within one-third the width of valve, and extending to the apices which are without nodules. Raphe exceedingly faint, running along the middle of its narrow area and not entering the central nodule. Striae on ventral side strongly divergent at the middle, slightly convergent towards the ends and parallel between; on the dorsal side more or less parallel throughout; at the poles strongly radiate. About the middle of valve the striae number 18–20 in 10 μ, towards the ends 22–24 in 10 μ, finely and delicately punctate (fig. D). Punctae 22–25 in 10 μ, but, owing to the fragile nature of the valve, not so readily seen as they would be if the siliceous shell were thicker. The foregoing features give this species a most distinct appearance when seen in valve view at a magnification of 1,000 diameters.

Frustule in girdle view almost linear, but tapering slightly towards the abruptly truncate ends (fig. B). Length as above. Breadth of the convex dorsal side 11–14 μ at the centre, 7–9 μ at the ends; the concave ventral side is slightly narrower (fig. C). The raphe of each valve is distinctly visible on each side of the dorsal aspect, each semi-raphe appearing as a faint line thicker at its middle (fig. B, *r*). The overlapping girdles are complex in structure. Each is from 5 to 7 μ wide, and is composed of five or more longitudinal zones of exceedingly delicate silex alternating with zones of thicker silex. These bear longitudinal rows of punctae which run about 30 in 10 μ (fig. E). It will be observed that in size and marking this species, like many other diatoms, is subject to considerable variation.

Each frustule contains two elongated chromatophores, each being about 14 μ long, and containing a distinct pyrenoid (fig.

B, *ch*). In the natural habitat of the living diatom the chromatophores are brownish, as usual in these plants, but on being gathered the colour quickly changes to green. This peculiarity was mentioned by Ralfs in Pritchard's *Infusoria* (1861). The change of colour may be due to hydrogen sulphide (H_2S) developing rapidly in the gathered material and reacting upon the leucocyanin and carotin of the chromatophores. In the process of multiplication by binary division the chromatophores each divide longitudinally into two parts, one part going to each new frustule. In division the two young valves of a double frustule separate first at the centre of the convex dorsal side, and ultimately at the ends. In the material supplied by "D. G." no other features of the reproductive process were observable.

This species is a free marine diatom living amongst the muddy sediment in rock pools within tidal influence. The following is an account by "D. G." of the habitat of his specimens:—"The gathering was made at a little seaside place called Pendine, nine or ten miles east of Tenby on rocks submerged at high water and bare of seaweed, but having little hollows and crevices containing a small quantity of mud."

Among a number of associate species the following interesting forms also occur in the gathering: Navicula scopulorum, *Bréb.*, Navicula (*Schizonema*) ramosissima, *Ag.*, and Toxonidia insignis, *Donk.*

Description of Plate 2.

Amphora inflexa, (*Bréb.*) *H. L. Sm.*

A. Valve view × 1,000 diams.; the dotted lines around this drawing indicate direction of striae. B. Girdle view of a frustule from dorsal side × 1,000 diams.; *r*, raphe which from this aspect becomes invisible towards centre and ends of frustule;

ch, chromatophore containing an elongated pyrenoid; *ge*, *ge*, overlapping edges of the two opposing girdles; *st*, striae on the girdles. C. Diagrammatic sectional view of a frustule; the heavy and light lines represent respectively the valves and girdles; the two dots indicate the raphe of each valve. D. Lineate transverse striae of valve × 3,000 diams., showing punctae. E. Longitudinal striae of girdle × 3,000 diams., showing rows of punctae alternating with zones of silex; the latter at this focus appear alternately light and dark.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the 536th Ordinary Meeting of the Club, held on October 8th, 1918, the President, Dr. A. B. Rendle, F.R.S., in the chair, the minutes of the meeting held on June 11th were read and confirmed. Eight nomination forms were read for the first time. Professor G. S. West, M.A., D.Sc., F.L.S., Mason Professor of Botany, University of Birmingham, was elected an honorary member of the Club.

Two papers, one by Mr. E. M. Nelson, on "The Binocular Microscope," and one by Mr. F. Oxley, on "The Magnifying Power of a Microscope and Some Methods of ascertaining it," were read in title.

Dr. Rendle exhibited a specimen of a Himalayan Aroid (*Sauromatum guttatum*). Attention was drawn to its resemblance to our British arum (*A. maculatum*) or Cuckoo-pint. The leaves of the plant exhibited are pedately divided on tall, stout, often mottled stalks, appearing after the spadix.

Mr. Grundy then read a paper by Mr. A. Ashe describing an incandescent gas lamp which he had devised for microscopical use. The object of the lamp is to provide a more concentrated light than that afforded by the ordinary mantle, and also to get rid of the pattern of the mesh that is so objectionable when the mantle is in focus. The burner found most suitable is a two-hole fish-tail acetylene burner, such as Bray's 00000, burning about one cubic foot of gas per hour. The incandescent cylinder is carried by a platinum or nickel wire lying in the same plane as the gas flame, and having its free end towards the observer, and bent up at an angle of 45°. The cylinders are made by cutting an ordinary upright mantle into strips about 1/4 inch wide and 2 in. or more long, rolling them round a knitting needle or smooth wire and securing the end by moistening it with the tongue. The cylinder is then slipped into the turned-up end of the wire, and so adapted as to give the best result. This adjustment is of great importance, and in order to facilitate it the wire and burner are clamped separately to an upright rod fixed in a firm base. Coal gas is generally used alone. By increasing the pressure the brilliancy of the light is increased, and if oxygen be used in conjunction with it the light is still more intense. Mr. Ashe suggested that attention should be given to some method of overcoming the drawbacks of the uneven surface of the roll, although it is much less apparent in the field of view than the mesh of an ordinary mantle. Mr. Traviss described some very ingenious modifications of the above lamp. In some of these he employed two or more jets, impinging on the cylinder symmetrically in the same plane in order to avoid one-sided pressure upon it.

Mr. Traviss also described a very simple form in which the burner was made from an ordinary burner having the holes filled up with plaster of Paris and a minute hole made in the side with a very fine needle after filing the side very thin in one place. The cylinder is carried by a wire (any wire will do) wound round the burner, and having its free end turned up at a right angle in front of the hole.

The President then called upon Mr. N. E. Brown to read his paper on "The Fertilisation of Figs." Mr. Brown said that he believed that the whole of the facts connected with the process had not yet been discovered. It is generally incorrectly supposed that insect aid is unnecessary, as good edible figs can be produced without it; but this is incorrect, for such figs contain no fertile seeds. Normally figs have three kinds of flowers—the common edible fig has also a fourth, an abortive, kind. The male and female figs are borne on different trees. Fertilisation has been carefully studied in *Ficus Roxburghii* and *F. carica* (the edible fig), and in both these species it has been shown that it cannot be effected by wind agency, but only by the introduction of pollen into the cavity of the fig by the fig-insect or by man. If the insect does not enter the fig the flowers within do not fully develop. In the case of *F. Roxburghii* (an Indian species) the male tree bears two crops, and the female tree two or more each year. From the bud to the time when the figs are ready for insects to enter is about two months for the male figs and three weeks for the female. The first male crop ripens in November and December, when the second male and female crops are fit for the insect to enter. The second male crop ripens in April and May, when the first male and female crops are ready for the insect to enter. The insect in this case is a species of *Eupristis.* If insects do not enter the figs at the proper time they dry up and fall off the tree. When the figs are ready for the insect the flowers are all nearly at the same level; the male flowers are whitish and the female and gall flowers pink. The male fig contains male flowers below and gall flowers around the "eye," and one to three insects enter each fig. The insect forces its way through the bracts which close the aperture of the fig, and begins to deposit an egg within the nucellus just outside the embryo sac of each gall flower. This causes the galls to form without injury to the fig, and also causes the male flowers to develop. The penetration is made through the tissue at the top of the ovary, and not by way of the style in this species, and this being tougher in the female flowers the insect cannot penetrate it, and dies, having, however, fertilised the female flowers by the pollen it has carried in. Some days after the entry of the insect the figs become filled with fluid, and the flowers elongate irregularly, so that they are not overcrowded. When nearly ripe the fluid is absorbed, and the male flowers develop and begin to shed their pollen. Then the Eupristes begin to emerge from the galls, the males, which have strong jaws, emerging first by cutting a hole in the gall. The males then gnaw a hole in each gall containing a female, and fertilise them before they come out. When all the females are free the males cut a tunnel through the eye of the fig, and in so doing cut away all the stamens, and all the insects are dusted with pollen. The males are wingless and soon die; the females fly away to find a fig fit for their reception, and seem unable to distinguish between male figs in which they can oviposit and female ones in which they cannot. Dr. Cunningham found that by the time the insect had got through the bracts into the fig most of the pollen was brushed off; he never found more than two or three grains inside a fig. From this he concluded that the number of pollen grains was insufficient to fertilise the thousands of ovaries in a fig, and that the insect's attempts to oviposit must be a sufficient stimulus to cause proper development as it is in the male fig. It has been shown, however, by Eisen over twenty years ago that in no single case has a female *F. carica* developed when the insects had not come into contact with any pollen before entering, while others on the same tree into which pollen had been carried matured, and there is no reason to suppose it is otherwise with *F. Roxburghii.* Dr. Cunningham found that the end of the pollen-tube enlarged into a globe into which all the contents collected. This burst and discharged thousands of minute granules. Mr. Brown said that this process required further investigation, and that he thought it possible that the granules might be the real elements of fertilisation, and that having been set free in the fluid which fills the cavity they would reach the stigmas. The dispersal of these granules may be part of the function of the fluid.

The fertilisation of the edible fig is much the same as that of *F. Roxburghii.* The insect effecting it is *Blastophaga grossorum.* In this case oviposition is stated to take place down the short style of the gall flower. The accounts of the fertilisation have been obscured by the fact that many cultivated varieties ripen their fruit without insect aid. To understand this it is necessary to bear in mind the following:—There are four forms of this fig: (1) The wild fig (Capri fig). This is the male tree, in the figs of which the insect breeds; they contain male and gall flowers, and in the third (last) crop *only* a few female flowers which produce one or two fertile seeds in each fig. (2) The Smyrna fig. This is the female tree bearing only perfect female flowers. (3) The common fig, bearing *only* abortive female flowers. These figs are purely a product of cultivation, and ripen just as bananas, seedless oranges, and other seedless fruits do. (4) A peculiar class of figs in which the first crop ripens without pollination, and the second, consisting of perfect female flowers, does not. The figs of the Capri fig are used for the process of caprification, which consists of hanging strings of mature Capri figs on the branches of the Smyrna (or other) figs, so that when the insects emerge from the Capri figs they may fertilise the Smyrna figs, which would otherwise drop off the trees. The Smyrna fig contains ripe seeds, while the common fig is seedless, containing only empty husks. The *Ficus* and the *Blastophaga* depend upon each other for existence. The *Ficus* could not produce seed and the *Blastophaga* could not breed without the other. Some species of *Ficus* may have their own kind of insect, but sometimes two or three kinds are found in the same species of fig.

A hearty vote of thanks was accorded to Mr. Brown for his interesting address.

The Secretary announced that there would be an informal "Gossip" Meeting on October 22nd from 7 p.m., and that the next Ordinary Meeting would be held on Tuesday, November 12th, at 7.30 p.m., when, in addition to some short communications, Mr. A. E. Hilton would read a paper on "Observations on Capillitia of Mycetozoa."

At the 537th Ordinary Meeting of the Club, held on November 12th, 1918, Mr. D. J. Scourfield, F.Z.S., F.R.M.S., Vice-President, in the chair, the minutes of the meeting held on October 8th were read and confirmed.

Messrs. Alan Faraday Campbell Pollard, Hy. Geo. Chislett, H. Bertram Harding, Fredk. Harold Dupré, Wm. Edward Rumsey, Walter Geo. Busbridge, Walter Joseph Magenis and Alfred Jas. Butler were balloted for and duly elected members of the Club; six nomination forms were read for the first time.

The Secretary announced that there would be a Gossip Meeting on November 26th, and that the next Ordinary Meeting would be held on December 10th, when there would be a paper by Mr. T. E. Wallis on "The Use of Amylic Alcohol and Sandarac in Microscopy" and a note by Mr. Morley Jones on "A Method of Mounting the Heads of Male Gnats."

The Chairman announced that Mr. Julius Rheinberg had presented to the club a set of scales and eyepiece micrometers. Most of the scales and micrometers are made by a method in which a photographically deposited metal is burnt into the surface of the glass, thereby making the rulings practically indestructible; not only are the lines beautifully clear and sharp, but the divisions are exceedingly accurate. Mr. E. D. Evens also presented twelve slides, and those who have seen Mr. Evens's preparations will know what a valuable addition he has made to the Club's cabinet. The thanks of the Club were accorded to both these donors.

The Chairman then called upon Mr. A. E. Hilton to read his paper, "Observations on Capillitia of Mycetozoa."

After some interesting remarks by Mr. Flower, to which Mr Hilton replied, the meeting closed with a hearty vote of thanks.

At the 538th Ordinary Meeting of the Club, held on December 10th, 1918, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on November 12th were read and confirmed.

Messrs. Ernest Robt. Martin, Lewis Wm. Kittle, F. Newton Williams, Wm. I. Ireland, Hy. Weaver and Robt. Wickham were balloted for and duly elected members of the Club; three nomination forms were read for the first time.

The Secretary announced that there would be no Gossip Meeting on December 24th, and that the next Ordinary Meeting would be held on January 14th, 1919. At this meeting nominations to fill the vacancies caused by the retirement according to rule of four members of the committee will be received, and the list of those nominated by the committee as officers for the ensuing year will be read. The ballot will be taken at the Annual Meeting in February.

The President stated that the question of admitting ladies to the membership and meetings of the Club had been brought before the committee. The feeling of the committee was that ladies should be admitted. There was no alteration in the rules necessary, as they were only excluded by tradition. Any member having any feeling in the matter should give notice to bring it before the Annual Meeting.

The President then invited Sir Nicholas Yermoloff to address the meeting in reference to Mr. Hilton's paper on the "Growth of Capillitia."

"Owing to the lateness of the hour at our last meeting, I was unable to take part in the very interesting discussion concerning Mr. Hilton's admirable paper on the Mycetozoa. With the President's and your kind permission I will say a few words now.

"In the course of his lecture Mr. Hilton said that some changes in the Sporangium observed by him under the microscope proceeded 'by jumps.' I hope I did not misunderstand the lecturer, but surely the so-called 'jumps' were only 'apparent jumps,' the changes appearing as jumps only because our senses are unable to perceive infinitely small variations in infinitely small intervals of time. In fact the variations are gradual and continuous, and there are, as a rule, and at least between certain limits, no jumps in Nature: *Natura non facit saltum.* This observation seems important because the notion of 'Continuity' in Nature brings natural phenomena, or variation in Nature, in close affinity to what is understood as 'Continuity' in mathematics: Continuity in mathematics means infinitely small variations in infinitely small intervals of time.

"Continuity is the general rule both in mathematics and in Nature; we find gradual continuity in most events and in most phenomena; it obtains even in such series of changes as, say, the study of some arts; fencing, practising on the violin and the like; I am told that progress in these practices is actually gradual and continuous, but realised both by pupil and master only as apparent jumps. What actually happens is this; for days and days no progress is noticeable, and then all at once a step forward is realised and the master can report progress. Here there is also undoubtedly a case of an 'apparent jump.'

"Now although Continuity in mathematics and in Nature is the general rule, yet it appears that there are exceptions to the Law of Continuity, certainly in mathematics, and probably also in Nature. Some mathematical quantities or elements are not continuous but discontinuous; discontinuous quantities being those that in an infinitely small interval of time truly effect a 'jump.' To state what such quantities are would lead me too far, but I may mention that the study of discontinuous quantities in mathematics has been recently taken up as a new branch of mathematical investigation, this separate branch having received the name of Arithmology. It is highly probable that discontinuity is to be found also in Nature; I am strongly inclined to think, for instance, that the actual passage from rest to motion, or from motion to rest, is a case of discontinuity showing something like a 'true jump.' But I repeat that such cases are probably only exceptional, the majority of natural phenomena being subject to the vast and powerful Law of Continuity."

In reply to these remarks, Mr. Hilton writes:

"The highly interesting comments made by Sir Nicholas Yermoloff relate to my description of the development of capillitium in a maturing sporangium of *Lamproderma columbinum*, as observed by me under the microscope. So far as the process was visible, development proceeded by rapid but intermittent movements, brief intervals of quiescence alternating with sudden extensions of branching threads; but there is no doubt whatever that these intermittent appearances were produced by a perfectly continuous and uninterrupted series of events. Actual breaks in the continuity of natural processes being, to me, unthinkable, I imagine that 'jumps' in Nature can only be changes of direction or velocity; and therefore Sir Nicholas and myself seem to be virtually in agreement. When Arithmology is more advanced it may be possible to determine whether 'discontinuity,' as defined by mathematicians, has any relation to biological processes. If it has, biologists will be specially interested in its application to certain vital problems; but we must 'wait and see.'"

The Secretary read a paper by Mr. Theodore Garnett, M.A., on *Notops brachionus*, var. *spinosus*.

In the month of September 1918 Mr. Garnett had the good fortune to find in a small mountain tarn in North Lancashire (about 450 feet above sea-level) a rotifer which he believed to be a new variety of *Notops brachionus*, but his attention has since been drawn by Mr. David Bryce to a note by Mr. Charles F. Rousselet to Mr. T. Kirkman's paper: "List of some of the Rotifera of Natal" (*Journal R.M.S.* 1901, pp. 229 to 241), which describes "a small variety of *Notops brachionus*. possessing two small hollow spines at the latero-posterior angles of the body, which seems to be widely distributed in South Africa," and which he named *Notops brachionus* var. *spinosus*.

Mr. David Bryce said that he was glad to be able to welcome Mr. Garnett as a new writer on the Rotifera, and complimented him on being the first to record this rotifer for the United Kingdom.

The President then called upon Mr. T. E. Wallis to read his paper on "The Use of Amylic Alcohol and Sandarac in Microscopy," describing the use as a mounting medium of a solution of sandarac (or gum juniper) in amylic alcohol. Sandarac is a resin obtained by incision from the stem of *Callitris quadrivalvis*, it is pale yellow, hard and brittle. The refractive index is a little less than that of the dried resin of Canada balsam, and equal to that of oil of cloves. It is easily soluble in ordinary alcohol, amylic alcohol, ether, and by heating in fixed oils; it is partially soluble in benzol, petroleum spirit, chloroform, and turpentine. Mr. Wallis exhibited some photographs to show the increased visibility obtained in some cases by using this medium instead of ordinary balsam. He also showed a photograph taken by dark-ground illumination to prove that the medium was homogeneous, and stated also that it showed no tendency to crystallise nor did the castor oil show any tendency to separate. A good clearing and dehydrating agent is made by dissolving phenol crystals in an equal quantity of amylic alcohol. This mixture has not the hardening and shrinking effects of clove oil or turpentine. Preparations may be transferred from it directly to the mountant.

After a few questions had been asked a hearty vote of thanks was passed to Mr. Wallis for his useful communication.

Mr. Morley Jones exhibited five slides of the heads of male gnats, and described the method of preparing and mounting them.

Mr. Grundy read a note by Mr. E. M. Nelson on the Optical Index. The Optical Index indicates the ratio of aperture to power, and is obtained by the formula:

$$\frac{1{,}000 \times \text{N.A.}}{\text{Initial magnifying power}}$$

or, which is the same thing, 100 × N.A. × focus in inches.

The following simple experiment should be performed by all those microscopists who take a scientific interest in the use of their instrument. It is well to remember that there is a vast interval between seeing a picture and reading about one. The only extra apparatus required is a visiting card and a sharp penknife. Place a suitable low-power test object upon the microscope stage (a blowfly's tongue would do very well), put a 2-inch objective on the nosepiece, and use a C eyepiece (× 10). Examine the image with attention; the optical index of the objective will be somewhere about 20 to 24. Now cut a stop in the card, with a central circular hole 6 mm. in diameter, place it at the back of the objective, and particularly note the difference in the image. The optical index will now be reduced to 12. (Of course a 3/4 cone must be used in each case.)

about the optical index of a 1/6th of 0·75 N.A., and this is greater than that recommended by Abbe as an ideal amount. I cannot urge too strongly all microscopists to perform this simple experiment, and to study carefully the two images. *The ideal optical index is* 25; *a good one for practical work is* 20. The 24 and 12 mm. apochromats of N.A. 0·3 and 0·65 are both over 30, and are therefore overdone, whereas those of 16 and 18 mm., with the same apertures, are 20, and are about right.

At the 539th Ordinary Meeting of the Club, held on January 14th, 1919, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on December 10th, 1918, were read and confirmed.

Messrs. Fredk. Thos. Gummer, Wm. Battle and W. S. Warton were balloted for and duly elected members of the Club; four nominations were read for the first time.

Dr. Rendle read out the list of nominations for officers for the coming season, and great satisfaction was expressed that he had again consented to be nominated to the presidency. Four members were nominated to fill the vacancies on the committee caused by the retiring of the four senior members, and the election will take place at the next meeting.

The President announced the death of Mr. L. C. Bennett, which took place just before Christmas. Mr. Bennett was well known to those members who attend the Club's meetings. In consequence of the Secretary's absence at the beginning of the meetings in the committee room, Mr. Bennett undertook to look after new members and introduce them to the Club. The kindly way in which he performed this office did much to promote the feeling of good fellowship in the Club, and his loss will be keenly felt by the members. Those present expressed their sympathy with Mrs. Bennett in her bereavement.

The following gifts to the Club were gratefully acknowledged:—Six slides from Mr. Evens; two slides of diatoms in "realgar" from Mr. Bowtell; and two photographs, taken by a member at one of the Club's excursions in 1890, from Mr. Chipps.

The Secretary announced that there would be a Gossip Meeting on January 28th, and that the Annual General Meeting would be held on February 11th, when Dr. Rendle would deliver his presidential address. Mr. Grundy then read a paper by Mr. E. M. Nelson on "A New Form of Polariser."

The thanks of the meeting were accorded to Mr. Nelson for his paper and to Mr. Grundy for reading it.

Dr. J. Rudd Leeson, M.D., F.L.S., then gave an address on "Flesh-eating Plants." Dr. Leeson said that when he was a small boy his nurse told him that animals were divided into three groups: birds, beasts and fishes, and this system of classification lasted until he found there were worms. Later on he was told that plants lived on CO_2, and that animals lived on plants, and then he found that there were some plants that lived on animals, and was again in difficulties. We cannot classify, Dr. Leeson said, except in ignorance. The difference between one living thing and another is caused by the specific character of the protoplasm. Protoplasm must have nitrogen, and there are some plants living in non-nitrogenous soils, such as on rocks or in bogs, that have taken to catching insects and other animals in order to supply themselves with this indispensable food-substance. There are about 500 flesh-eating plants, and they may be divided into three groups according as they capture their prey: (1) by means of chambers or traps; (2) by means of movements; (3) by a sticky excretion. Many examples may be seen at Kew. The pitcher-plants have developed pitchers, often provided with a cover on which honey is secreted, and a brightly coloured rim, which serves to attract insects. Once inside, and being unable to climb out owing to a row of teeth below the margin, they make futile attempts to escape through the semi-transparent wall and eventually fall into the water at the bottom of the pitcher and are drowned, their bodies being digested by the pepsin from the digestive glands and absorbed by special hairs or cells. The same thing happens in the case of the bladderwort. The bladders look remarkably like large water-fleas, and the entomostracans and other water creatures, having pushed their way in, find a trap-door has shut behind them, and, their way of escape closed, they are soon suffocated, digested and absorbed. The leaf of the butterwort is covered with digestive and absorbent hairs, and insects stick to its surface. If an insect alights near the edge of the leaf there is a curling of the margin, which pushes it farther on, so that it is soon overwhelmed by the digestive juice which is poured on to it. It has been estimated that there are as many as half a million glands in one plant. The sundew leaf is even more remarkable. It is covered with sensitive glandular hairs, which, as soon as the insect or a piece of nitrogenous food such as flesh or cheese comes into contact with any of them, bend over and close upon it. Digestive juice is then poured on to the food, and the tentacles remain closed until absorption is complete, which may be several days. There are 200 tentacles on each leaf, and they are able to move through an angle of 90° when excited, in ten minutes, while in one to three hours they have closed entirely over their prey. If small stones or other objects containing no nutriment are put on to butterwort or sundew leaves, no notice is taken of them. If two bits of meat are put on to a sundew leaf the tentacles divide into two groups, half closing over one piece and half over the other. If a large insect becomes caught on a leaf, the leaf becomes hollow like a hand, so that it may enclose it more easily, and if it is very large two or three leaves may co-operate. Dr. Leeson described the structure of the tentacle by means of a drawing. He thought it might give some indication of the origin of nerves, and showed how the impulse acted on the purple liquid in the cells surrounding the central parts, causing aggregation of the cell-contents.

Dr. Rendle described an Australian species of climbing sundew, in which some of the leaves responded to the touch of twigs, etc., so as to enable the plant to climb, while others acted as insect traps.

A vote of thanks was accorded to Dr. Leeson for his address.

At the 540th Ordinary Meeting of the Club, held on February 11th, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on January 14th were read and confirmed.

Messrs. Fredk. B. Gibbard, Robt. Edward Handford, Chas. Fredk. Brightman Shillito and Geo. Abraham Tolley were balloted for and duly elected members of the Club ; two nominations were read for the first time.

The Secretary announced that there would be a Gossip Meeting on February 25th, and that at the next ordinary meeting on March 11th there would be a paper by Mr. Geo. West, of Dundee, on "A Marine Diatom," and one by Mr. C. D. Soar on "The Genus Oxus." This being the Annual General Meeting, the Secretary read the names of the officers and committee nominated for the ensuing year; and as there was only one nomination for each vacancy, no ballot was necesary, and the meeting confirmed the election of the nominees by show of hands.

The balloting list was as follows:

BALLOTING LIST FOR THE ELECTION OF OFFICERS, FEBRUARY 11TH, 1919.

For President . .	A. B. Rendle, D.Sc., F.R.S., F.L.S.
For Four Vice-Presidents .	Prof. Arthur Dendy, D.Sc., F.R.S., F.L.S., F.Z.S. D. J. Scourfield, F.Z.S., F.R.M.S. David Bryce. R. Paulson, F.L.S., F.R.M.S.
For Treasurer . .	Frederick J. Perks.
,, *Secretary* . .	E. K. Maxwell, B.A.
,, *Assistant Secretary*	Jas. Burton.
,, *Foreign Secretary*	C. F. Rousselet, F.R.M.S.
,, *Reporter* . .	A. Morley Jones.
,, *Librarian* . .	Alfred George.
,, *Curator* . .	C. J. Sidwell, F.R.M.S.
,, *Editor* . .	A. W. Sheppard, F.R.M.S.

For four members of Committee:
G. H. Gabb, F.C.S.
M. A. Ainslie, R.N., B.A., F.R.A.S., F.R.M.S.
Jas. Grundy, F.R.M.S.
Jas. Burton.

Mr. J. Wilson moved a vote of thanks to the retiring officers, expressing the thanks of the members to them for having successfully led the Club through difficult times. Dr. Leeson, in seconding the motion, which was carried by acclamation, spoke of the friendly spirit for which the Club was so well known, and which had contributed so largely to its success.

The President, in replying, said that the officers were grateful for the support they had received, and that, although the officers must do their duty, the effectiveness of a society lies ultimately with the members, without whose loyal support the society must come to grief. Having worked together during strenuous times, he hoped they would continue to work together during the difficult times yet to come. Dr. Rendle referred to the vacation by the Club of their present premises, and expressed the hope that it would soon be possible to announce that satisfactory arrangements had been made for removal to a new home.

The Hon. Secretary then read the Committee's 53rd annual report, and the Treasurer read his report and balance sheet. The reports showed the Club to be in a satisfactory condition, the membership having increased to 453, being 19 more than last year.

The President then delivered his annual address, taking as his subject "Some Cases of Adaptation among Plants."

Dr. Rendle was unable to finish his address owing to the lantern not being available. He will deliver the remainder of it at the next meeting on March 11th.

A hearty vote of thanks was accorded to the President for his interesting address.

As he is shortly leaving London for some time, Mr. James Burton has been compelled to resign the Hon. Secretaryship, and the opportunity was taken of thanking him for all the work he had done for the Club. Mr. Burton, in reply, expressed his regrets that he had to relinquish the office, although he had held it at such a difficult time, and congratulated the Club on having found such an able successor in Mr. E. Kelly Maxwell.

FIFTY-THIRD ANNUAL REPORT.

In presenting the Report for the year ending December 1918, the Committee feel that perhaps the Club may be most appropriately congratulated on the absence of any very outstanding incident. For the greater part of the period covered by this Report, the unfavourable conditions caused by the long continuance of the war prevailed. Yet notwithstanding these, the usual meetings were held at the regular times, and the attendance, though suffering somewhat, was good. Since the conclusion of the Armistice, and the relaxation of the lighting restrictions, a larger number of members have found themselves able to be present. During the year, 35 new members were elected, which is one more than in the previous year; 10 resigned; and 6 were removed by death; the total membership being 453.

The Club lost a very well-known and most useful member in Mr. L. C. Bennett, who died suddenly on his way to business on December 21st. For a considerable time he has most efficiently performed the service of welcoming visitors and new members; and by his introductions to those already present, and by his own genial and attentive manner, has succeeded in making them feel at home at once, and also to realise the comradeship with which the Q.M.C. always meets those new to its Society. We shall all miss him greatly. His special personal interest was with the rotifera.

We still have to deplore the continued inability of Mr. C. F. Rousselet to attend the meetings, owing to the precarious state of his health, which we are grieved to hear is now even more unsatisfactory than previously.

Two new honorary members were elected during the year—Mr. T. H. Powell, who, till his great age, combined with the difficulties caused by the war, prevented it, was regular in his attendance, was elected in February. Professor G. S. West, M.A., D.Sc., Mason Professor of Botany in Birmingham University, was elected in October.

As for several years past, there have been no exhibits of new apparatus by opticians, owing to their energies being monopolised for government purposes. In this connection, however, mention may be made of a number of pieces of apparatus, thought out and made by our member, Mr. W. R. Traviss, and exhibited and described at the meetings, often giving promise of great usefulness to the working microscopist.

The more important papers read during 1918 are as follows:

Papers and Communications during 1918.

January 8th.—Mr. J. M. Offord, F.R.M.S., exhibited micro-preparations of Anopheles, the mosquito which spreads malaria.

February 12th.—Dr. A. B. Rendle: Presidential Address: "The Use of Microscopic Characters in the Study of the Higher Plants."

March 12th.—Paper by Mr. G. T. Harris, on *Schistostega osmundacea.* Also a paper by Mr. Williamson, F.R.S.E., and C. D. Soar, F.L.S., on the Freshwater Mite, *Lebertia sefvei.*

April 9th.—Sir Nicholas Yermoloff, K.C.B.: "Notes on some Intermediate Forms of the Genera *Cymbella and Navicula.*" Also a paper by Professor G. S. West: "A Further Contribution to our Knowledge of Two African Species of Volvox."

May 14th.—Mr. F. Martin Duncan, Vice-President R.M.S.: "Insects as Transmitting Agents of Disease."

June 11th.—An Address by the President: "On Some Points in the Structure and Growth of Grasses."

October 8th.—Exhibit of a Himalayan Aroid, *Sauromatum guttatum,* and description by the President. A paper by Mr. Ashe, F.R.M.S., read by Mr. Grundy, describing an incandescent gas lamp for microscopic work. Two papers, one by Mr. E. M. Nelson on "The Binocular Microscope," and one by Mr. F. Oxley on "The Magnifying Power of a Microscope," were read in title.

November 12th.—Mr. A. E. Hilton: "Observations on the Capillitia of Mycetozoa."

December 10th.—Summary of a paper on *Notops brachionus,* var. *spinosus*—Rousselet, by Mr. Theodore Garnett. Also a paper by Mr. T. E. Wallis, B.Sc., on "The Use of Amylic Alcohol and Sandarac in Microscopy." Mr. Arthur Morley Jones, "Notes on the Preparation of the Heads of Male Gnats for Micro-mounting."

The Committee, on behalf of the members, thanks the authors who have given them the pleasure and profit of these interesting communications. The Club is under obligation to Mr. E. M. Nelson, as on so many previous occasions, for his valuable papers and descriptions of new adjuncts to the microscope, which are to be found detailed in the *Journal* and *Proceedings*.

Excursions, 1918.

In presenting a report on the Excursions held in the year 1918, there is nothing unusual to add to those of former years. During the year, nine excursions were held, at which the average attendance was 17·1, being smaller than that for several years. This was due to the restricted train service and increased rates, while the unfavourable weather in April and September considerably interfered with those who usually attended the favourite excursions to the Royal Botanic Gardens, Regent's Park, and to Northwood and Ruislip respectively. On June 22nd the Club visited the private grounds at Syon House, permission having been granted by His Grace the Duke of Northumberland. The excursion held on July 27th, to Richmond Park, was very interesting, although the attendance was small. Through the kindness of Dr. G. H. Rodman, the party was enabled to visit the private grounds of Sudbrook Park, and afterwards hospitably entertained to tea.

Books Purchased for Library.

Growth and Form. Prof. D'Arcy W. Thompson.
Manual for Study of Insects. I. H. and A. B. Comstock.
The Organism as a Whole. J. Loeb.

Books Presented to Library.

British Fungus Flora. G. Massee.
Presented by H. H. Mortimer.
A Manual of the Infusoria. W. Saville Kent.
Presented by F. Hughes.

THE NATURAL HISTORY OF PLANTS. F. W. Oliver and A. Kerner. 2 Vols.
Presented by DR. J. RUDD LEESON.

Exchanges and Journals received from:
American Microscopical Society.
Academy of Natural Science.
Brighton and Hove Natural History Society.
Croydon Natural History Society.
Edinburgh Royal Society.
Glasgow Naturalist.
Geologists' Association.
Hastings and Sussex Naturalist.
Hertfordshire Natural History Society.
Illinois Biological Monographs.
Missouri Botanical Gardens.
Manchester Literary and Philosophical Society.
Photomicrographic Society.
Photographic Journal.
Philippine Journal of Science.
Quarterly Journal Microscopical Science.
Royal Society.
Royal Society of New South Wales.
Royal Microscopical Society, Journal of.
Royal Dublin Society.
Torquay Natural History Society.
U.S. National Museum, Bulletin of.
U.S. National Herbarium.
Victorian Naturalist.
Wisconsin Academy.

The Hon. Curator reports that there has been an increase in the number of slides lent out over previous years; thirty-two preparations have been added to the cabinets, due to the generosity of two members. A very interesting donation was made by Mr. Rheinberg of a set of stage and eyepiece micrometer scales, prepared by a special photographic process he has worked out, and which can be borrowed by members under certain conditions. The production of such scales was formerly practically a German monopoly and the Club is to be congratulated on the ingenuity of one of its members in rendering such effective national service.

The revision of the collections, and preparation of the new Catalogue, has been steadily proceeded with by the Curator. All the botanical slides, and the zoological sections up to the Crustacea, have been dealt with, and a revised manuscript catalogue is now at the disposal of members for reference. It is interesting to note how well some of the preparations have stood the test of time, many of them mounted forty to fifty years ago being still in perfect condition. During the past few years many gaps have been filled up in groups formerly unrepresented, although there are a good many shortcomings still to remedy; the kind generosity of members may be appealed to for this purpose. Sections of all Invertebrates, and preparations illustrative of mitosis, would be especially welcome.

A considerable number of members have of late expressed a wish that ladies should be eligible as visitors at the meetings, and also be admitted as members. This, though formerly thought undesirable, would evidently be in accord with modern tendencies, most of the Scientific Societies having adopted the course suggested. The Committee on examining the rules found that the step was not in any way forbidden; and the matter being put to the vote, a large majority were in favour of the procedure.

Another noteworthy circumstance that occurred just at the end of the year is that it appears the Club will have to look for a new home; the landlords having given notice that the tenancy which expires next Midsummer will not be renewed. The Hon. Secretary, to his great regret, has felt it necessary to ask the Committee to accept his resignation, as probably he will be leaving London before the end of the Session, most likely for a considerable time. He would like to remind members that the war has been creating difficulties through almost the entire period during which he has been in office. The Club may be congratulated on having without delay found a most efficient substitute, with whose assistance it may well anticipate that its progress will be assured and enhanced.

As in past years the thanks of all are due to Mr. Bestow and Mr. Gardner for the help they have given to the Curator in his arduous duties; and to Mr. Offord for the large amount of trouble he has taken in the by no means easy task of managing the lantern; also to Mr. Morley Jones, who has furnished the *English Mechanic* with most excellent reports of the proceedings and papers read at the meetings. The Committee desires to thank the officers for their care, and attention to the interests of the Club during the anxious period which has been passed through; reminding both them and the members that it is obvious that here, as elsewhere, conditions in the future will of necessity be different from those that have hitherto prevailed. At the same time it may be pointed out that new conditions furnish new opportunities, and that adherence to the sound principles which have brought success to the Quekett Microscopical Club, during the more than half-century of its existence, will produce the continued prosperity and usefulness which is the aim and wish of all.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

For the year ending December 31st, 1918.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance from 1917	109	1	5	By Rent	75	0	0
,, Subscriptions	194	0	0	,, Expenses of *Journal*	80	2	9
,, Dividends	14	1	2	,, Postage, etc.	3	8	4
,, Sales of Journal	13	3	0	,, Printing and Stationery	11	4	0
,, Advertisements	4	19	6	,, Attendant	3	12	6
,, Catalogues	0	17	5	,, Petty Expenses	1	11	0
				,, Books and Slides	7	4	0
				,, *English Mechanic*	8	16	6
				,, Balance in hand	145	3	5
	£336	2	6		£336	2	6

INVESTMENTS.

	£	s.	d.
$2\frac{1}{2}$ per cent. Consols	334	1	6
Metropolitan Water Board Stock	100	0	0
Metropolitan Stock	100	0	0
$2\frac{1}{2}$ per cent. Annuities, 1905	100	0	0

We have examined the above Statement of Income and Expenditure and compared the same with the Vouchers in the possession of the Treasurer, and have verified the Investments at the Bank of England, and find the same correct.

January 28th, 1919.

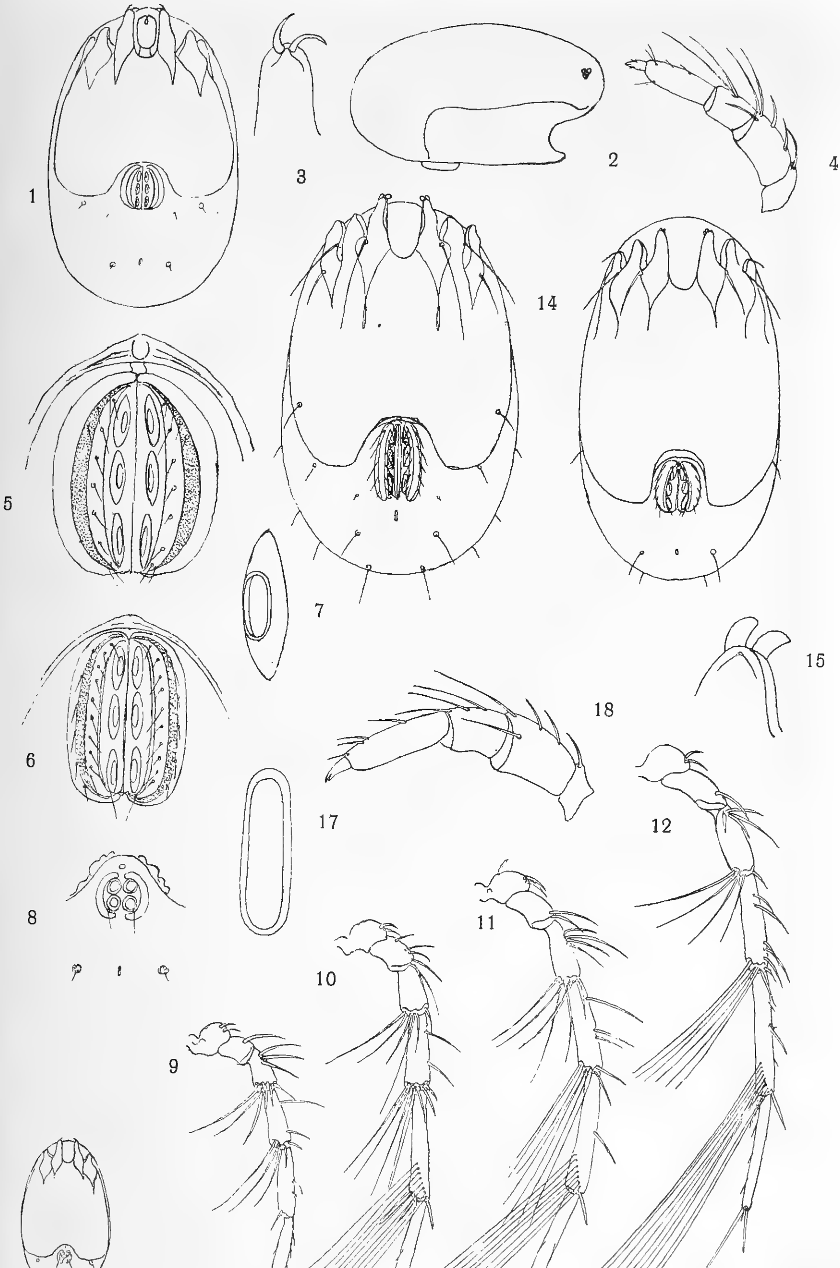
JAMES C. MYLES }
J. WILSON } *Auditors.*

FREDK. J. PERKS, *Treasurer.*

TABLE FOR THE CONVERSION OF ENGLISH AND METRICAL LINEAR MEASURES; YARD AT 62° F. AND METRE AT 0° C.

1 ÷	mm.	1 ÷	μ	1 ÷	μ	1 ÷	μ	1 ÷	μ
2	12·70	27	941	53	479	79	322	125	203
3	8·47	28	907	54	470	80	317	130	195
4	6·35	29	876	55	462	81	314	135	188
5	5·08	30	847	56	454	82	310	140	181
6	4·23	31	819	57	446	83	306	145	175
7	3·63	32	794	58	438	84	302	150	169
8	3·17	33	770	59	431	85	299	155	164
9	2·82	34	747	60	423	86	295	160	159
10	2·54	35	726	61	416	87	292	165	154
11	2·31	36	706	62	410	88	289	170	149
12	2·12	37	686	63	403	89	285	175	145
13	1·95	38	668	64	397	90	282	180	141
14	1·81	39	651	65	391	91	279	185	137
15	1·69	40	635	66	385	92	276	190	134
16	1·59	41	620	67	379	93	273	195	130
17	1·49	42	605	68	374	94	270	200	127
18	1·41	43	591	69	368	95	267	205	124
19	1·34	44	577	70	363	96	265	210	121
20	1·27	45	564	71	358	97	262	215	118
21	1·21	46	552	72	353	98	259	220	115
22	1·15	47	540	73	348	99	257	225	113
23	1·10	48	529	74	343	100	254	230	110
24	1·06	49	518	75	339	105	242	235	108
25	1·02	50	508	76	334	110	231	240	106
	μ	51	498	77	330	115	221	245	104
26	977	52	488	78	326	120	212	250	102

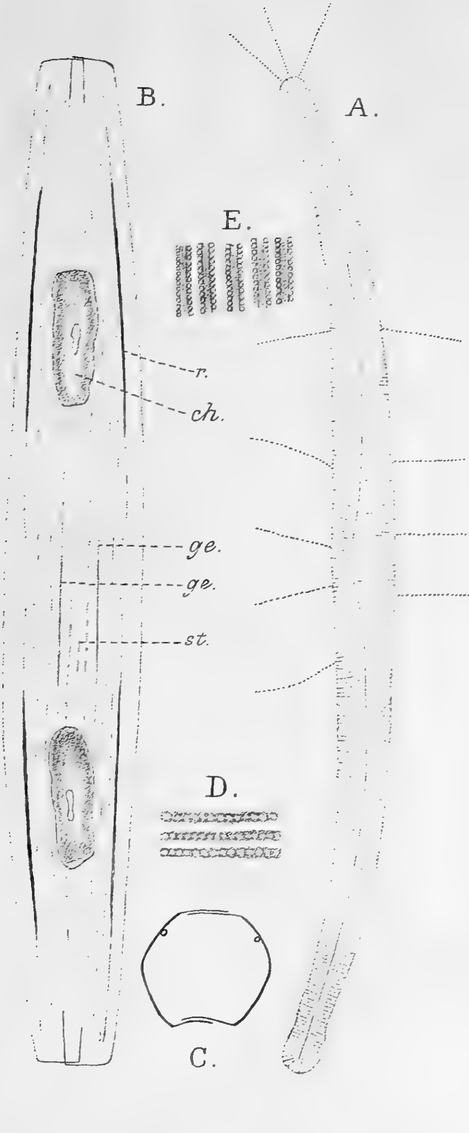
As the measurements of many microscopical objects are given in fractions of an inch in English literature, and in metrical measure in foreign works, the above table has been drawn up to facilitate comparison. Its use is obvious. Examples: 1/7th inch = 3·63 mm., 1/58th inch = 438 μ, or ·438 mm. For fractions smaller than 1/250th inch that portion of the table between the figures 26 and 99 may be used by cutting off the last figure for hundredths, and the two last figures for thousandths. Examples: 1/270th inch = 94·1 μ, or ·0941 mm.; 1/7900th inch = 3·22 μ, or ·00322 mm. When that portion of the table between the figures 100 and 250 is used it is only necessary to cut off the last figure for thousandths. and the two last figures for ten thousandths. Examples: 1/1350th inch = 18·8 μ, or ·0188 mm., 1/16500th inch = 1·54 μ, or ·00154 mm. The conversion of millimetres into fractions of an inch is performed in the same manner; thus, 529 μ or ·529 mm. = 1/48th inch; 39·7 μ or ·0397 mm. = 1/640th inch; 2·62 μ or ·00262 mm. = 1/9700th inch; 1·04 μ or ·00104 mm. = 1/24500th inch; ·977 μ or ·000977 mm. = 1/26000th inch, and so on.—E. M. N.



del. ad nat. C. D. Soar.

Hydracarina: The Genus Oxus.

Adlard & Son & West Newman, Ltd.



Del. ad nat. G. West. Adlard & Son & West Newman Ltd. lith.

AMPHORA INFLEXA.

THE AMATEUR MICROSCOPIST DURING WARTIME.

By E. Kelly Maxwell, B.A.

(*Read April 6th*, 1919.)

Figures 1 and 2 in Text.

It was my good fortune, during the war, to spend about a year at a very picturesque little town in Northern France. From the tall ramparts that completely surround the town, there is a lovely view over the peaceful rolling country all around, and one looks over the tops of the trees to see the river that flows along a winding valley, here and there giving a silver gleam back to the sky, while from the citadel that guards the northern gate one looks out along the widening marshy course of the river to a far distance, where two tall white lighthouses speak of passing ships and the ocean. The name of the town tells that once the sea was near, but that was long ago. During the eighteen months or so previous to my arrival here I had often cast a secret eye of longing at likely ponds and ditches in Flanders—and there are many around Bailleul and in the direction of Ypres—and at times I had inquired of priests, chemists, and other likely people whether there were any local pond-hunters, but without success. The quest was not entirely unfruitful, however, as it led to a very interesting hour in the private museum of an old doctor, who had a very fine specimen of young mammoth which he had obtained from the quarries of Arques. It was not until I came as sergeant-major to a company on duty near the little town on the hill that my enthusiasm was roused to action by meeting a kindred spirit. This was a tall sergeant of my company, a keen lover of nature, who, when a day off duty came, enjoyed nothing better than a long walk in the country, field glasses in his pocket, eye and ear ever on the alert to pick up, here a stone-chat perched on a stump, there a curlew skimming with plaintive note over a marsh, or a blue tit, as we came striding along, darting for cover. He was one of those rare people who can keep a diary going for years; and many a delightful hour we spent over his notes of wild flowers and birds observed since we arrived in France. It was in one such hour we heard of a microscope given to him as a boy, and of some wonderful creature that darted across the field of view with something whirligigging in front like an aeroplane propeller. This was the beginning of many a talk of rotifers, and one of the first results was a set of little outlines in his notebook of the commoner forms, such as Melicerta, Limnias, Stephanoceros, Floscularia, Philodina, Brachionus, Euchlanis, and other well-marked varieties. After the sketches naturally the next thing was to find the living specimens, so after fitting up little cigarette tins with watch glasses, pocket magnifiers and bits of mirror after the fashion of dissecting stands, we applied ourselves to the quest. Our first rotifer was a bdelloid from a piece of moss picked off the wall of the Citadel, near the North Gate. The flat swampy fields just outside the low outer walls of the town yielded us very soon *Triarthra longiseta, Polyarthra platyptera*, Euchlanis and several small loricate forms such as Salpina and Diglena. A big marshy field not far from the ramparts, where we often saw curlew and other sea birds, gave us our first Hydatina. This was the first time I had ever taken this fine form. Always, however, I was longing to get one of the big tube builders to show my tall sergeant, and I shall never forget the day we got our first one. We had gone for a walk to the north of the town on the wide marshes of the river, and as luck would have it we had no collecting bottle with us. We came upon a number of low-lying gardens, separated by little drains leading into one of the big marsh pools. I was so struck by the likely-looking growth of Anacharis that we forthwith started to hunt for a bottle. Strange to say, old bottles of any sort seemed very absent on this particular day, and at last at a lonely railway crossing we found the Frenchwoman on duty had a lot of empty beer bottles. We persuaded her to part with one for fourpence, and set off again to the pool, looking back on our way to find her regarding us with a very puzzled, not to say comical, expression. I suppose she had never found empty bottles so much appreciated before! Our zeal was rewarded handsomely, however, when on turning out the contents into several shallow dishes, later in the day, we found two specimens of Stephanoceros and a fine big *Brachionus urceolaris*. All our finds were of course seen by the hand glass simply, and I was delighted to find that the tall sergeant was getting quite able to distinguish a number of different types of rotifer by their movement and size. Many of my readers will perfectly understand that, on recalling to mind the appearance of, say, a Philodina swimming or crawling, Synchaeta, called the "swallow of the waters," Brachionus with tail anchored and wagging its body violently, Pterodina of dainty shape and almost disappearing edgewise, Anuraea with its everlasting somersaults, Polyarthra skipping with the speed of light, Triarthra with its long flashing sword blades and Euchlanis in its glorious crystal armour.

All the time it was becoming very obvious that we should have to bring more instrumental power to bear, and as it did not seem to be practical politics to get a valuable instrument out under our uncertain conditions, I determined to rig up some makeshift kind of microscope. With the object glasses of a pair of little Galilean telescopes I made an objective of about 2-in. power, and this tried with a brown-paper tube and wooden limb gave such promise that I fitted up a wooden tripod stand with a spot lens substage made from a 1-in. flash-lamp lens. On the large wooden stage a sliding bar held by a pair of rubber bands made a very efficient support for the slides, which were cut from broken window glass with a file, the cover-glasses being of the same material, and supported on the slip by three tiny pellets of cobbler's wax. And so our first microscope was launched, the beginning of what was known to those in the secret as the "Royal Society." Shortly after this we got a Melicerta, and the first séance with a candle and condenser in our little tent on the hill-side to see Melicerta is unforgettable. The optics of this extraordinary instrument would hardly pass the scrutiny of the brass and glass experts, but after an aching desire for magnification it was some solace to see a sizable picture. The dark-ground effect was there of course, but the details reminded me of some of Joblot's pictures, in which he got over these finicking minutiae by drawing a man's face on the object. My glowing description of the ciliary movement and the mastax, and the eagerness of such a promising pupil to see them, however, did not let us rest content; so after some tantalising delays I had sent out to me a body and draw tube, 2/3rd and 1/6th in. objectives, double nosepiece and eyepiece, with a few excavated slips and cover-glasses. I had grave fears as to the searching demands of a 1/6th in. as regards stand and adjustments, but in the sacred cause of science I plucked up courage. The old wooden stand, good enough for a very doubtful 2 in., was rather shaky with the 2/3rd in. and impossible with the 1/6th in., and after some attempts to stiffen it I began to look about for suitable metal fittings. I spent hours and hours beguiling shopkeepers, all friendly, but some very inclined to be suspicious of a buyer who made excuses to get peeping into drawers and searching their stores for likely bits of brass. What I wanted was something to act as a guide or slide, and at the same time offer some hope of an adjustment by screw or otherwise for focusing. At last I found what I wanted. In the stoves one finds all over Flanders and Northern France there is very often a damper, *i.e.* a flat disk mounted on a spindle passing through the stovepipe, and moved to increase or shut off the draught by turning a key handle on the end of the spindle. The spindle I found was square with screw thread cuts on the edges to take the nuts which kept it in position. The square fitted in the damper and turned it. I got a blind-cord strainer of the kind in which a vertical bar carrying a pulley slides in holes in two projections from a base plate. I opened out these holes until they fitted as closely as possible, but easily, on the damper spindle. Using the spindle as a tap, I forced a thread in the vertical part of a furniture castor, after removing the pin, and a keyhole plate clamped between this and one of the nuts on the spindle formed the stage. The base plate of the cord strainer sliding on the damper spindle against a spiral spring placed round it, and pushed down adjustably against it by the remaining nut, formed a sliding carriage to which was attached by carpet tacks a wooden block carved out to take the sleeve in which the body tube of the microscope fitted. The jaws of the castor jammed on a wooden upright completed the model No. 2. A shaving glass propped up below served for mirror. With the 2/3rd in. we were able to see clearly ciliary movement and mastaxes now. With the 1/6th in. our first object was a desmid, *Closterium Lunula*, focused only with considerable care. But the 1/6th in. was not a success with this. The carriage, as it jumped briskly from point to point of the serrated edges of the guiding limb, did not recommend itself to the scientist at the eyepiece, chasing the elusive object at every jolt. At this time, by great good fortune, there arrived from my old company as pioneer a man who was an excellent amateur mechanic. He was quite accustomed to the use of the microscope, and on seeing my efforts up to date he proposed to have some of his tools sent out from home. These arrived later, and comprised a good bench vice, taps and dies up to 1/4th in., hack-saw, files, brace and bits and soldering outfit. As model No. 2 was so unsatisfactory, the substage problem was deferred until a solution of the adjustment problem above the stage was reached.

I began to look out for a sliding fitting with less play in movement. In this wearisome quest for something suitable, I made friends with a kindly old man in a shop near the South Gate, who allowed me to search drawer after drawer in his shop until at last in a guide for a sliding plate-glass show-case front I found what I wanted, a substantial brass block with a steel strip dovetailed into it. It took the leisure of three days to get the working of the dovetail sweet and without shake, working at it with razor paste. I spent weeks trying to find a piece of rack and pinion in vain, and finally recollected the motion of the "Argus" stand. Getting a number of little grooved brass rollers from window blind fittings, I cut them two at a time into worm wheels with a tap, and made a dozen before I could get two to work smoothly enough on the best screwed bar I could produce. The screwed bar is an ordinary six-inch nail. The attachment of this rod to the slide was no small difficulty. To recall the items of construction, and their innumerable variations in the progress to a final efficiency, would be too tedious; but in the figures it will not be difficult to recognise the large and small castor jaws forming the knuckle joint, the large castor wheel cut in two to make coarse adjustment heads, the small wheel, the fine-adjustment head; the heavy scutcheon of a keyhole forms the stage, the little dovetail attachment underneath it carrying a substage bracket, made from window-blind fittings, a substage ring cut from a shaving-soap box, tailpiece of fishing-rod joint, and gimbal (very effective, after hours of work and making and re-making) holding a mirror made from a shaving-soap box lid and a penny shaving-glass cut down. The feet are detachable, and comprise a blacksmith's dividers held by a dummy cartridge screwed on to the pin of the small castor. To get the original rivet out of the blacksmith's dividers was no small job, effected at last by heating in a shoeing forge with horses champing and stamping around. The condenser originally used was quite satisfactory, and was made of a large flash-lamp lens, about 1 in. diameter, with its tin cone, into which was stuck with

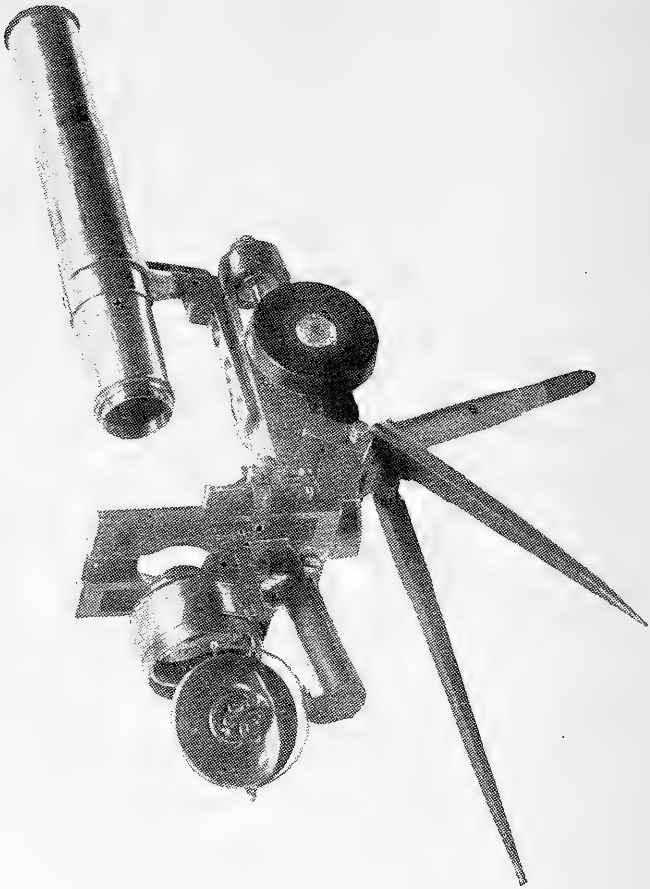


Fig. 1.—Side View.

cobbler's wax a small lens of the same sort, the combination mounted in a blind-roller end cap. (The condenser shown in the figure was brought out later from home.) The block attached to the dovetail slide which carries the sleeve fitting of the body is half a butt hinge, a piece of the remainder of which appears in the pretentious clamp for locking the body at the right inclination. Last of all the sliding bar, all odds and ends, but its velvety

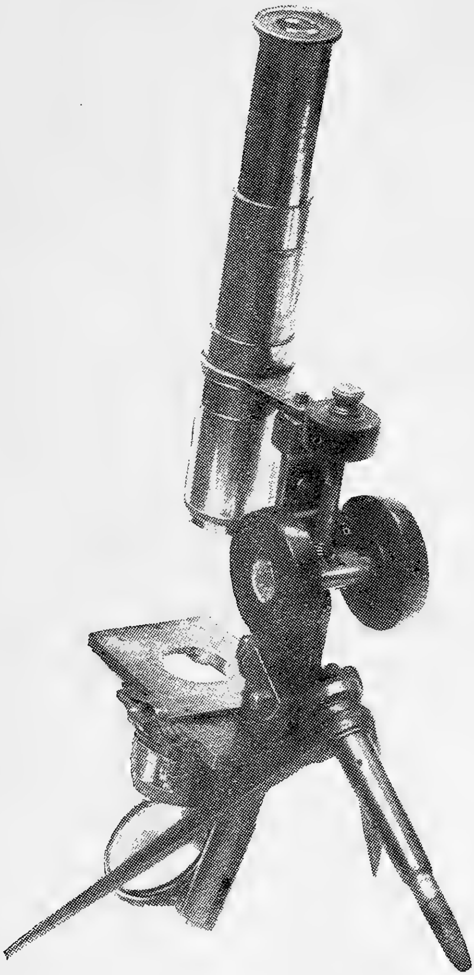


FIG. 2.—BACK VIEW.

motion and its stop-dead action had quite the feel of the professional article in use. And so at last we had a microscope with which it was possible to find and focus an object with the 1/6th in. and leave it so that another could see it. Thus equipped we essayed some of the regions till then denied to us. Diatoms were a source of great interest, and rotifers now showed their cilia and mastaxes on demand. The first sight of a flame cell in a rotifer marked the new advance. Now that the mechanical difficulties were settled, the " Society " acquired a new popularity. One lucky dip taken direct from the little stream in the village on to the slip, contained half a dozen lusty Hydatinae, and hosts of Euglenae and slipper animalcules. Such sights as these were very popular, and Madame, our excellent hostess, became an interested visitor of the Society. I have a charming recollection of the visit of her two little children to a séance: the wee girl, after a lot of coaxing, took an eager hurried peep at the wriggly things down the tube, and clung with frightened pleasure to her mother's skirt. Melicerta we found again away towards the Estuary.

The floscules found in the days of model No. 1 we never found again; but the finest haul of diatoms and desmids I've ever had we found under two feet of water in a delta-shaped patch where one clear stream met another at right angles. In surface water lying on a field for several weeks I found *Pterodina valvata*, considered rare by Hudson and Gosse. Its delicate lorica folded at each side was very transparent, almost invisible. In the marshes we found Volvox and the purple Stentor. Along the river bank, a mile or two from the sea, we once found a hoof mark filled with water faintly milky-looking; this was due to countless hosts of Synchaeta, a form rather smaller than *S. pectinata*, of which, however, there were a fair number. A rotifer talked of for long before we found it was Dinocharis, but at last we captured this dainty form. We paid a considerable amount of attention to moss, because there was plenty about the district. The roofs of several places in the village yielded *Philodina citrina* and *P. roseola*, fine big forms, as well as more ordinary forms like *Rotifer vulgaris;* an Adineta with curious sudden movement in crawling. Some rather unusual infusorians we took in the moss, among which I remember most clearly a species of Folliculina. We kept Hydatina under observation, and managed to get the fourth generation of one individual by the cobbler's wax and thick cover-glass method. The " Society " was generally fortunate in its expeditions. A little knob of moss, about the size of half a golf ball, collected from an old wall contained an extraordinary number of bdelloid rotifers and water-bears.

Opportunities arose at times for bathing in the sea, and our first "find" in a little pool in the sand consisted practically entirely of the polyparies of polyzoa and zoophytes; of which I made out at least six different species. These of course were all dead, but the empty tubes contained many fine diatoms, polycistina and foraminifera. Another marine expedition gave us some fine specimens of medusa buds, of a kind of Obelia, with sixteen tentacles to the bell. We got several alive under the microscope; but still more pleasing was the fairy beauty of the adult polype like an exquisite flower in its crystal cup. This lost nothing by being seen on a glorious summer afternoon with a jocular nightingale, a familiar friend of ours, singing exuberantly a few yards off. At night in our little tent we were able to see the tiny flashes of light on tapping the bottles containing the polype.

A call to sterner duty came one day, and dissolved the "Society."

When next I had opportunity to turn my attention to the old pursuit, it was strangely enough not far from the same district. I had no instrument but a pocket lens, but the "microscopic" specimen was not difficult to see, being nothing less than a huge patch of plasmodium of a mycetozoon crawling on an old fungus-covered log in the garden of the little farm-house where I was billeted. The daily change was readily seen as it threw out a front line and communication lines in a bright orange network, until it was quite 30 inches long and about half as wide. This was in December 1917. I watched it until a few days' dry frost seemed to dispel it, and presently there appeared in the more shady and obscure parts of the log the purple berry-shaped masses of sporangia. It was about five or six years previously that I had been first initiated into the fascinating mysteries of the mycetozoa, and I had often searched for them, but without success. It was with no small delight, then, that I detached and sent home some of the magnificent first haul of "myxies." I lost no time in searching in a little wood near for more, and, after diligent investigation of a number of old rotten tree stumps, managed to secure three further different species.

So! I have shown you this little cameo, clean cut to me at least, standing out from all the tangled experiences of the dire years of war. The horses stamping and champing in the gloomy forge while I toiled like Vulcan to get the rivet out of the dividers—the first glimpse of my friend at the beautiful flower-like polype, outside our tent on the hill-side, with the most wonderful nightingale in France in full song a few yards away—the shy little French girl clutching at her mother's skirt after peeping into the magic tube—the gallant men from London and Peru, Panama and Bonnie Scotland, who formed the delightful "Royal Society" on the little French hill-side.

Note.—The specimens exhibited at the reading of the paper were some of the polyparies mentioned, viz. :

Hydrallmania falcata (Lin.).
Abietinaria abietina (Lin.)
Idmonea serpens (Lin.).
Sertularia operculata.
Obelia (? species).

and the mycetozoa collected in the little wood, viz. :

Badhamia utricularis (from the log at my billet).
Arcyria denudata.
Trichia inconspicua (var. *contorta*) (possibly also *affinis*).
Physarum pocillum.

I gladly take this opportunity of expressing my indebtedness to the President, Dr. Rendle, F.R.S., for getting the zoophytes named for me at very short notice, and to Mr. Hilton for revising the nomenclature of my specimens of mycetozoa.

MICROSCOPIC ILLUMINATION.

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(*Read May* 13*th*, 1919.)

Communicated by the Hon. Editor.

Section I.

Theoretical Aspect of Microscopic Illumination.

It has been stated (**1**) that the principal difference between the rival theories of microscopic vision lies in the mode of regarding the illumination of the object: whereas the Fraunhoffer theory traces the light from the object, as if the object itself were self-luminous, the Abbe theory considers the light from its source.

This cannot be true, for the "source" of Abbe's theory is not the source of light, except under exceptional circumstances; but usually it is a virtual source, placed at infinity and of such dimensions that the trains of plane waves illuminating the specimen appear to be proceeding from it. In support of this view the following evidence may be advanced.

(1) In the "Diffractions-Platte" experiments which were designed to prove his theory of microscopic vision, Abbe directed that a distant point source of illumination be used in conjunction with the plane mirror. This is the most convenient means of obtaining a beam of sensibly parallel light with the ordinary microscope without special apparatus. In this case the theoretical consideration of the optical processes which precede the formation of the final image clearly starts at the source; but as will be shown immediately, this is the only case in which it does do so, for in the following cases the source is not the source of light.

(2) In the special apparatus which Abbe had constructed for

his own researches into the image formation in the microscope, a small circular aperture and a collimator were used to provide the necessary plane-wave illumination. In this case the source of light was placed behind (and therefore at an appreciable distance from) the small circular aperture, which therefore itself became the source from the point of view of his theory. Even if he had focused an image of the source into the plane of the small aperture, as in modern spectroscopic practice, that would not have made the aperture behave like *a source* of light. It would seem clear, therefore, that " the source " in this case is definitely not the source of light, but a virtual-point source placed at infinity from which the plane waves produced by the aperture and collimator may be considered to have started (" virtual " being here used in precisely the same sense as that used when speaking of the *virtual* magnified image produced by an eye-piece).

(3) For low-power work with the microscope Abbe advised the use of daylight and the plane mirror. This restriction to low-power work is not due to any fundamental difference in the method of image formation in objectives of low and high power (Abbe was most emphatic on this point; " even fence poles," he said, " are seen by the formation of images according to my theory "), but is due to the artificial restriction to the angle of plane-wave illumination which the method provides. (The use of the phrase " angle of plane-wave illumination " may perhaps require explanation. Imagine plane-wave illumination to be proceeding to a specimen lying on the microscope stage from a number of sources placed at infinity. If the number of sources is so immense that they join together to form a hollow sphere of light, then it is clear that although the illumination is everywhere due to plane waves, since these come from infinity, still it is also correct to express the extent of the illumination as seen from the specimen in angular measure.)

(4) For medium powers Abbe advised the use of the concave mirror in conjunction with daylight, and for high-power work the employment of the uncorrected condenser which bears his name; the object in both cases being to increase the angle of illumination. He therefore regarded daylight as the ideal illuminant, not only without the condenser, but also with it. Now in neither case is the sky the light source, for the small

particles which reflect the light to the observer are themselves directly or indirectly lit by the sun, and therefore the source is in this case also not the source of light, but the virtual sources placed at infinity from which the plane waves illuminating the specimen may be regarded as being derived. In the case where the plane mirror alone is used, the plane-wave illumination commences from the sky; with the Abbe condenser in addition, it starts *as spherical waves* from points situated on the lower focal plane of the condenser (for only under this condition can plane waves leave the upper lens surface of the condenser).

Now Abbe's emphasis on the use of *plane-wave* illumination for the microscope was probably made for two reasons: firstly, when this is the case the spectra formed in the upper focal plane of the objective would have their greatest purity in the spectroscopic sense (the specimen on the stage being the counterpart of the diffraction grating or prism); secondly, it would be possible to confirm by calculation the images seen by the eye, in those cases where plane waves are incident on the specimen (the treatment for curved-wave fronts being of very much greater mathematical complexity). But this emphasis on the use of plane waves by Abbe does not imply that any practical advantages follow their use. In fact my own experiments serve to show that great divergence from plane-wave illumination is permissible without obvious change in the images presented to the eye. There are probably two reasons that may be advanced for this experimental fact: firstly, as Johnstone Stoney (**3**) has pointed out, there appears to be physical reality for the mathematical theorem that any train of simultaneous vibrations may be replaced by an equivalent series of plane waves; secondly, only in quite exceptional cases (ruled gratings and very regular diatoms such as *Pleurosigma angulatum*) are the conditions present for the formation of pure diffraction spectra, and therefore the distribution of intensity in the maxima and minima would under ordinary conditions be but little affected by the substitution of an incident beam of light with a curved instead of one with a plane-wave front. This is in agreement with Conrady's views (**4**), for he showed that with curved-wave fronts the image must still be formed on the diffraction principle.

SECTION II.

THE POSITION OF CRITICAL ILLUMINATION.

It has been held by many experienced microscopists, and by the British school in particular, that critical light differs from illumination of every other kind when applied to the microscope, and that the images produced only reach perfection when critical light is employed (Nelson). As is well known, critical illumination is obtained when the image of the source corresponds point for point with the specimen under examination. The source should be small in order that the observer should know when an accurately focused image has been formed in the plane of the specimen. The use of a condenser with definition as perfect as that of objectives is logical, since the correction of spherical and chromatic aberration is of the highest importance if the image of the source and the specimen are to correspond point for point. Assuming that a perfect condenser lens system can be obtained, three questions arise for consideration: firstly, to what extent are the ideals of critical illumination compatible with the Abbe theory; secondly, are its ideals realisable; and thirdly, can they be realised in practice?

With regard to the first question. According to the Abbe theory, the source is so situated that plane waves illuminate the object. If on the other hand with critical illumination point-for-point illumination of the object is to be realised, then the source must be so situated that convergent waves from it meet at points coincident with the plane of the specimen. The source on the basis of the Abbe theory cannot therefore be identified with that required for critical illumination. Further, according to the wave theory of light, permanent and therefore visible interference can only occur between waves which have proceeded from the same source, or from sources in constant phase with one another. And further it is found by experiment that, in the case of most ordinary sources, interference can only occur if the light waves have proceeded from the same part of the source. Combining the above, we find that the different parts of a source radiate independently of one another. Now if in critical illumination a perfect image of the source were formed on the specimen, then one part of the smallest specimen receives light which bears no phase relationship to that falling on any other part, and therefore even if the specimen is a periodic one (such as a ruled grating or diatom) no visible interference fringes should be formed in the upper focal plane of the objective. But it is an essential feature of the Abbe theory to suppose that the whole of the specimen is lit by coherent light (that is light between the different parts of which a definite phase relationship exists) and that interference occurs because of this fact. The ideals of critical illumination, therefore, appear to have no justification on the basis of the Abbe theory.

With regard to the second question. Its ideals are unrealised, for whereas with perfect critical illumination no interference fringes (diffraction spectra) should be formed in the upper focal plane of the objective, yet formed they undoubtedly are, as the classic experiments of Abbe and Johnstone Stoney, and the confirmatory experiments of many other observers, suffice to show. The following may be quoted: Abbe's experiments convinced him that spectra produced by interference do exist in the upper focal plane of the objective. Johnstone Stoney (**3**), in the case of a spectroscope, under the most ideal conditions possible for the realisation of critical illumination, proved that interference took place to a degree that would have been impossible if critical illumination had achieved its purpose. Its failure was due, it appeared, to diffraction, since the optical system employed was such that the aberrations usually found in microscopic apparatus were almost completely eliminated. In reference to question 3 it will be observed that the ideals of critical illumination are unrealisable, because even if the aberrations of the condenser lens system are completely eliminated, diffraction (being due to the nature of light itself) still remains, and is alone sufficient (because of the representation of every point as a system of rings) to destroy the realisation of point-for-point illumination.

In cases where the edge of a paraffin flame is used as a source of light a further reason exists, as Conrady (**6**) has shown, why critical illumination cannot achieve its ideals, namely, because the depth of the illuminant prevents the simultaneous focusing of all but one section of the flame.

We must conclude therefore that critical illumination has no theoretical advantage, and the question therefore arises as to the cause of its continued employment. Two reasons may be advanced; firstly, it is (when properly applied) one method by which the full aperture of the objective may be filled with a uniform and well-centred cone of light; secondly, the use of the flame edge restricts the illumination to a portion of the field and therefore reduces stray light, which causes less fatigue to the eye than if the whole field is flooded with light.

If the ideals of critical illumination are contrary to the Abbe theory, how is it that the images which it yields are not surpassed by other methods of illumination? The only possible explanation is that critical illumination has survived not in spite of, but because of, its imperfections.

Section III.

Alternative Methods of Illumination.

The superiority of critical illumination being illusory, the existence of other methods of illumination equal to or superior to it must be looked for.

According to the Abbe theory, the ideal position for the illuminant, when a condenser is used, is at approximately the lower focal plane of the condenser, for under these circumstances light-rays leave the top surface of the condenser as nearly parallel bundles. Such a position is an impractical one in almost all cases, because of the closeness of the lower focal plane to the bottom lens surface. In certain condensers the lower focal plane is actually within the lower combination. I therefore used the alternative method of throwing a magnified image of the light-source into the position of the lower focal plane of the condenser by means of a bull's-eye condenser, which was itself placed at the correct distance from the substage condenser. This bull's-eye lens was a Petzval combination, being aplanatic and corrected for chromatic aberration. Immediately in front of the bull's-eye was mounted an iris diaphragm, so that the size of field illuminated by the substage condenser could be controlled. As illuminant I employed the flame of a paraffin lamp placed broadside on, so that its focused image should completely fill the aperture of the substage condenser. Care was taken to cause the flame image to coincide with the lower focal plane of the condenser. This adjustment was effected by first focusing an auxiliary microscope on the upper focal plane of a 4-mm. Holoscope objective (the plane of the image formed by the objective of distant objects being used) and then using the combination for observing the adjustment of the flame image in the lower focal plane of the substage condenser.

(The use of an aplanatic lens system, and the careful adjustment for obtaining plane-wave illumination may seem to be at variance with what I have stated above, namely, that for practical purposes the employment of plane-wave illumination appears to be unnecessary. These precautions were used because I was not convinced, at the time these experiments were made, that plane-wave illumination could be dispensed with. This system of illumination is that which Ainslie (2) has called system A, because he believed it to have been originated by Abbe for the purpose of obtaining illumination with plane waves. Ainslie has pointed out that while the method itself is valuable, the importance of plane-wave illumination is doubtful, and probably the best procedure in practice is to focus the image of the source on to the plane of the iris diaphragm of the condenser, wherever that may be.)

The substage condenser used was a Conrady "Holos" oil-immersion system of 1·35 N A., this combination being chosen because of its high correction. Tests showed, however, that there were residual amounts of under-correction, both for aplanatism and chromatic aberration. The usual test for aplanatism (namely with the flame image in focus on the specimen to examine whether the back lens of the objective appears completely filled with light) is unreliable because it varies with the size of the flame. An alternative and better test is to watch for movement in the image of a small source focused on the slide when a slit-shaped aperture is moved below the condenser, so as to expose different condenser zones. This method is analogous to that which I have described in a separate paper under "tube-length adjustment" (7). Details of the technique will be found described there.

This test, which is very searching, showed that the condenser was under-corrected for spherical aberration in the peripheral zones. This could be eliminated by methods similar to those applied in the case of objectives, that is by increasing the optical tube length, or by separating the components of the lens system (equivalent to using a correction collar). An auxiliary positive lens system was therefore placed below the condenser which was chromatically over-corrected, eliminated almost completely the chromatic difference of magnification, and was found to improve slightly the spherical correction.

This method appears to be exactly analogous to that described by Ainslie (**5**). The fact that the lens in my case was over-corrected chromatically does not constitute an essential difference.

The images given by this complete condenser system were found to be satisfactory; the comparison between the different methods of illumination was therefore proceeded with.

Section IV.

Experimental Comparison between Different Methods of Illumination.

The three alternative methods used were:

(1) Critical illumination in which an image of the illuminant is focused into the slide.

(2) First alternative in which an image of the illuminant is focused into the lower focal plane of the condenser (called by Ainslie method A).

(3) Second alternative in which a piece of opal glass is placed at the lower focal plane of condenser, the opal glass being illuminated from behind by a suitable light-source (Sir A. E. Wright's method).

The apparatus was arranged so that the change from one to another illuminant could be rapidly effected, at the same time retaining precise adjustment.

The following tests were applied:

(1) The resolution of a replica grating by Thorpe of 14,000 lines to the inch. A Baker objective of 40-mm. focal length was used, above the lens being mounted a Davis diaphragm.

(2) *Pleurosigma augulatum* into both lines and dots (40,000 lines or dots to the inch). A dry 4-mm. Holoscopic objective 0·95 N.A. was used, immediately above its back lens being mounted a Davis diaphragm.

(3) *Amphipleura pellucida* into both lines and dots (96,000 lines to the inch). A Zeiss apochromatic objective of 1·4 N.A. was used. No Davis diaphragm was employed.

The following method was used in making the comparison. With the objective carefully focused on the slide, the iris diaphragm of the condenser and the Davis diaphragm (in the case of the 40-mm. and 4-mm. objectives only) were adjusted so that the required resolution of lines or dots was obtained. The diaphragms were now gently closed till resolution was seen to break down in some part of the field; this was found to happen more quickly when the Davis diaphragm was closed than was the case with the substage iris.

DIAGRAM 1.

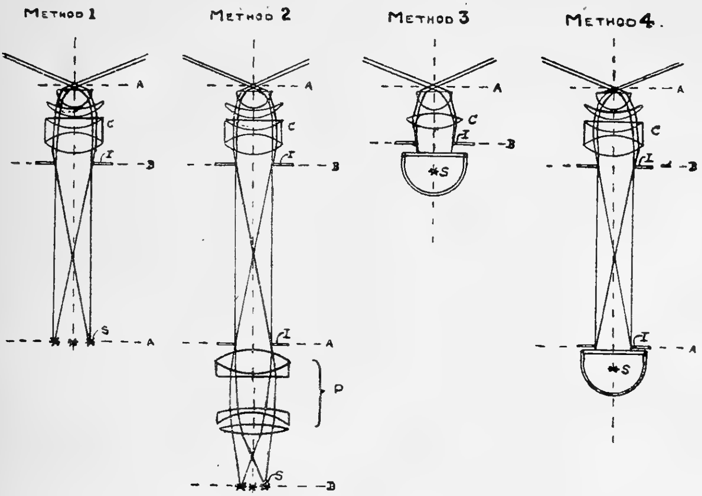


DIAGRAM TO SHOW THE FOUR ALTERNATIVE METHODS OF ILLUMINATION REFERRED TO IN THIS PAPER.

A = A plane co-ordinate with slide.
B = A plane co-ordinate with upper focal plane of objective.
C = Substage condenser.
I = Iris diaphragm.
P = Petzval "bull's-eye" condenser.
S = Source of light.

When the appearance had been carefully noted, the other illuminants were substituted.

Any improvement in resolving power would be at once shown by the appearance of structure in those parts of the field where the resolution had broken down owing to the closure of the iris. Any decrement, on the other hand, would have shown itself by a further breakdown of the image.

In the case of the resolution of *Amphipleura pellucida* a specimen mounted in realgar was employed. It was found that great care had to be taken to eliminate spherical aberration from the images of both condenser and objective. Further it was found advantageous to use an eyepiece with a small field of view. It was found that even then the resolution into dots was to be observed in parts of the field only.

On performing these tests, I was unable to find any change whatever in the resolving power of these objectives, nor were details apparently changed in any of the specimens. When colour filters were used in order to restrict the illumination to chosen parts of the spectrum, no variation in this conclusion was found necessary. I was therefore unable to find any difference between critical illumination and the two alternative methods so far as the resolution of the microscopic image was concerned.

Apart altogether from resolving power, there is the further question as to the advantages of restricting the field of illumination, for both Ainslie and I have found that when this is done the image appears more distinct, and may be examined for longer periods without fatigue. This is probably due to two causes:

(1) A physical one—namely, less scattered light from parts of the optical system between the slide and the eye.

(2) A physiological one—namely, a reduction in the fatigue of the retina, and possibly also increased contrast.

There appear to be two ways of obtaining a restricted area of illumination: firstly, by closing an iris diaphragm fitted at the lower focal plane of the eyepiece (this method is independent of the system of illumination); secondly, to restrict the illumination of the slide to that portion which (when magnified) will fill the chosen part of the field of the eyepiece (this method necessitates that an iris or other diaphragm be co-ordinate with the slide, and therefore excludes the use of methods of illumination, such as nos. 1 and 2, which do not possess this feature). Of the two alternative schemes the second is the better, since the elimination of scattered light is more complete. As pointed out above, however, a very well corrected condenser is required in order that the first method shall be definitely outclassed.

Section V.

The Relative Advantages of Different Methods.

One advantage of the opal-glass method (3) is that an uncorrected condenser (Abbe type) can be employed. This may be used dry or with water or oil immersion. The method is unaffected by slide thickness, since spherical aberration may be neglected. The disadvantages of the method are (*a*) that it is not possible to limit the illumination to a portion of the slide, (*b*) that small sources (such as an arc lamp) cannot be economically employed (so that the method is not good for projection). The advantages of method 2, system A (2), is that illumination can be limited to a portion of the slide, thus reducing stray light, and that small sources can be economically used. The method has therefore important advantages for photomicrography and projection. The disadvantage of the second method is that a highly corrected condenser lens system must be employed if its full advantages are to be obtained. Slides of different thickness then require a correction for tube length when the condenser is used dry, or a change made in depth of top lens when used with immersion oil. The first method (critical light) has neither the advantage of simplicity possessed by method 3, nor is it so good for photomicrography or projection as method 2, since the light cannot be restricted at will to a portion of the slide.

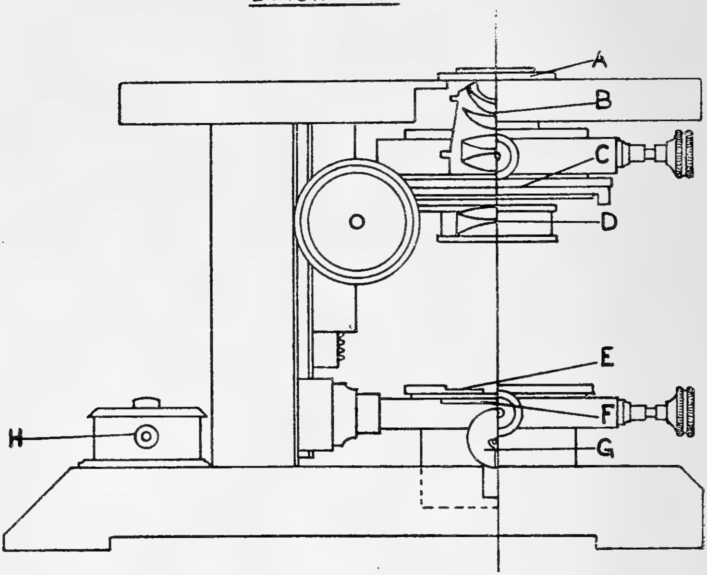
Consideration of the above leads to the following opinion. In the ordinary use of the microscope, method 3 (opal glass) provides an inexpensive and simple technique, quite adequate for histological and medical purposes. Its results are equally good with all powers. For research work with the microscope and for projection and photography a more elaborate technique based on methods 1 and 2 must be employed (the latter being preferable). A convenient arrangement for research which has the advantages of those methods, and provides ample illumination even for high magnification, is shown in the diagram at (4). For projection I have found most suitable the method called by Ainslie system B. In this an image of the light-source is formed by a chromatically uncorrected condenser in the plane of the iris diaphragm, an image of which is focused on to the slide. For closing this iris greatly reduces the intensity of the heat rays.

Section VI.

Practical Applications.

I have developed and applied to my own microscope this last system of illumination (method 4), since it forms a very convenient arrangement. Below the iris diaphragm of the condenser is mounted an auxiliary lens which removes the chromatic under-correction of the condenser, and also reduces the effective "tube length"; for instead of the source being placed at 6 in. approximately in order that spherical aberration may be absent, it has now to be placed at $1\frac{1}{2}$ in. only. At this position is placed an iris diaphragm which is mounted in a centring collar, the ring of which is attached to the dove-tail slide in place of the mirror (see diagram 2). Below this iris is a slip of flashed opal glass

DIAGRAM 2



ARRANGEMENT OF SUBSTAGE FOR METHOD 4.

A = Slide.
B = Immersion condenser.
C = Iris of condenser.
D = Auxiliary lens.
E = Iris of illuminant.
F = Opal glass disc.
G = Electric lamp.
H = Switch.

which is illuminated from behind by a 4-c.p. 4-volt Osram lamp. The light-source is therefore attached to the microscope itself, an arrangement which has the following advantages:

(1) The condenser being an oil-immersion lens system, "tube length" is kept constantly at the best setting.

(2) The light-source is always central with the optical axis of the microscope.

(3) Tilting or moving the microscope does not upset the adjustments.

(4) When the iris of the illuminant is fully open, a large uniform source is obtained suitable for low-power work, by closing down the iris, or by slipping in small perforated discs the illumination may be restricted to a portion of the field, even with a magnification of 1,000 diameters.

(5) The intensity of the illuminant may be controlled at will by means of a simple adjustable resistance.

(6) The illuminant is not visible to the observer.

(7) Optical errors are not introduced by the use of the plane mirror.

The first three advantages allow the microscope, when removed from its case, to be ready in complete adjustment for immediate use. Further, very seldom is it necessary, since the condenser is an oil-immersion system, to make changes in the positions of any of the parts of the substage system. (Flint slides, or those in which realgar is used as medium, are the only cases requiring readjustment that I have found.) The disadvantages of using an oil-immersion condenser are entirely due to slides not being of a standard thickness, since some slides are too thick for the working distance of the condenser, while others are so thin that the immersion fluid tends to leave the gap between the slide and the condenser front. Water has therefore been proposed as an immersion fluid, since its high-surface tension tends to hold it in place by capillarity. Its refractive index is, however, so low that different thicknesses of slide require different distances between the condenser and illuminant. Ainslie (**1**) has suggested the use of glycerine, but its refractive index is still found to be too low for its employment as an immersion liquid. The use of the immersion condenser in practice would, however, appear to be facilitated in the following ways:

(1) To provide a simple gauge which would test whether a slide is too thick, correct, or requiring to be increased in thickness by the addition of another layer of glass.

(2) To employ an immersion fluid of the same refractive index, but much higher surface tension than that of cedarwood oil.

Both these suggestions have been tested, and the results will be published in detail in a future paper. The arrangement of condenser and substage described above in fig. 2 has been found suitable for objectives from 1/3rd in. to 1/12th in. The diameter of the illuminated portion of the slide was found by measurement to be one-tenth (approximately) the diameter of the iris of the illuminant. The iris can be varied from 20 mm. to 1 mm., and the field therefore altered from 2 mm. to 0·1 mm. For high-power work smaller circles of illumination are sometimes required; these may be obtained by dropping into the iris grooved brass discs the centres of which have been drilled with small apertures. In this way the illumination may be limited to 0·01 mm. diameter. Smaller apertures than this would not serve any useful purpose because 0·01 mm. is approximately equal to the diameter of the maximum aberration disc of the condenser system. The illumination with this apparatus is found to be suitable up to one thousand diameters magnification approximately, but for objective testing or very high-power work greater illumination may be required. This may be obtained by using a small half-watt with a frosted bulb, the opal glass being omitted. For greater intensities still the bulb may be coated with a thick deposit of silver, and then a small aperture of the required size scratched away and then frosted, so that the light issues from this as if from a source of the required shape and size. The intensity otained in this way is very great indeed, since nearly the whole of the illumination of the lamp has to find its way out through this aperture. (I have used the same method for obtaining a fine linear source of great intensity suitable for a monochromatic illuminating apparatus with complete success; details of this apparatus will be given in a future paper.) The life of such a lamp does not seem to be very long, but doubtless improvement could be effected in this direction. It is possible that painting the outside of the silver coating with dead black varnish would facilitate the radiation of heat, and thus prolong the life of the filament. An alternative and apparently equally good method would be to place an ordinary bulb within a metal box, the inside surface of which has been silver plated and highly polished. This box would be perforated with an aperture of the required shape and size. The outside of the box could be ribbed and painted dead black, so as to keep the box cool.

For work (usually with low powers) where the use of an oil-immersion condenser may be considered unnecessary, I employ a dry uncorrected Abbe condenser, which is fitted with a pair of auxiliary lenses, so as to employ the same source of light and fittings as the more highly corrected oil-immersion condenser. The field illuminated by this system is large enough for quite low-power work, and is found to be convenient, because the aberrations which are obviously present do not matter for such purposes. Of course in cases where a low-power lens is required to do its best, the use of the more perfect condenser lens system would be clearly indicated.

Ainslie has described very completely the principles underlying correct microscopic illumination. He has pointed out that the disadvantage of method 1 lies in the fact that the illumination of the slide is not uniform, and that this may be a serious objection for photography. There is the further disadvantage described by him, and mentioned earlier in this paper, that since the illumination cannot be restricted to the portion of the field corresponding to the photographic plate, there is some reduction in the brilliance and crispness of the image owing to the scattered light. Ainslie points out that method 2 does not possess these disadvantages, for the illumination of the field is uniform, and its extent may be restricted at will by the iris diaphragm on the bull's-eye. He shows, however, that it has the disadvantage that the aperture of the substage condenser —and therefore that of the objective—*may* not always be uniformly illuminated. In many cases it will be more brilliantly lit at its centre than at its edges; which results, when a solid cone of illumination is in use, in coarse details being more brilliantly represented (since they require rays of small N.A.) than fine details. The reverse is sometimes the case, *i.e.* edges more brilliant than centre; which causes the fine details to be unduly prominent. I wish to point out that this difficulty may be almost eliminated, at the expense of a certain amount of light, by placing a slip of finely ground glass between the iris and the bull's-eye. The illumination of the aperture of the condenser becomes almost uniform under these conditions. Ainslie has himself pointed out that unless the largest possible illuminated area of the object is imperatively required, it is generally possible to select a small uniform area in the light-source, and to project this on the aperture of the substage condenser iris so as to fill it completely. This may require a bull's-eye of very short focus, and therefore very close to the light source; obviously undesirable with an arc lamp in use on account of the risk of overheating and consequent damage to the bull's-eye. It is, however, generally possible—with high powers at any rate—to obtain a large illuminated field without special difficulty in this respect.

Ainslie further points out that if the distance between condenser and bull's-eye is increased with a view to obtaining a large enough image of the light-source to fill the aperture of the substage iris, it is well to have the " bull's-eye iris " separately mounted, so that its distance from the condenser may be varied to suit the thickness of the object slip.

May I take this opportunity of thanking Commander Ainslie for the valuable suggestions that he has made to me during the revison of this paper.

Summary.

(1) The source from which the rays are traced, according to the Abbe theory, is only in exceptional cases the source of light.

(2) The ideals of critical illumination are contrary to the Abbe theory, and if obtained would destroy resolution.

(3) The ideals of critical illumination are unobtainable in practice. It is because of this that the technique of critical illumination has survived.

(4) With a carefully designed optical system for obtaining critical illumination, the minimal working aperture required to resolve certain test objects was ascertained. No decrement in the resolving power could be found when two other systems of illumination were substituted.

(5) One of these systems provides a very simple technique for applied microscopy. The other has marked advantages for photomicrography.

(6) A fourth method is found to give very good results and to be convenient in practice. Details of this method are described and illustrated.

References.

1. Spitta. *Microscopy*, 1907, p. 401.
2. Ainslie. *Proc. Photomicro. Soc.*, 1918, p. 1.
3. Johnstone Stoney. *Journ. Roy. Micro. Soc.*, 1897, p. 71.
4. Conrady. *Journ Roy Micro. Soc.*, 1904, p. 631.
5. Ainslie. *Journ. Quekett Micro. Soc.*, 1915, p. 561.
6. Conrady. *Journ. Roy. Micro. Soc.*, 1904, p. 612.
7. Hartridge. *Journ. Roy. Micro. Soc.*, 1919, p. 119.

NOTICES OF BOOKS.

Fresh-water Biology. By Prof. H. B. Ward and Prof. G. C. Whipple, with the collaboration of a staff of specialists. $5\frac{3}{4}$ in. × 9 in., ix + 1,111 pages, with 1,547 text figures. (New York: John Wiley & Sons, Inc. [London: Chapman & Hall, Ltd.], 1918. Price $6, or 28*s*. net.)

Elaborate monographs on fresh-water organisms as a whole, and on single groups, have appeared in various European countries, but until the appearance of this important work no such attempt had been made to deal with North American fresh-water life in its entirety. We may say at the outset that this volume will prove to be quite indispensable in the biological laboratory, and wherever biological problems are studied in other than a superficial manner.

The first few chapters are devoted to a discussion of general biological factors, and the mass of material relating to the problems and methods of hydrobiology condensed into the chapter on "Conditions of Existence" renders it particularly valuable to the general student of whatever country he may be. Each of the special chapters is devoted to a single group of organisms, animals or plants, and conforms to the same general plan throughout the book, with the exception of the chapter dealing with Aquatic Vertebrata. A general account of the occurrence and history of the group is followed by a description of the anatomy of the forms treated, dealing chiefly with such features as are of special value in the synoptic key. Similarly the life-history is given in condensed form. Attention is devoted to the general biological relations of the group, special features being left for later treatment under the individual species, except where they illustrate general questions. Care has been exercised to include descriptions of special methods for collecting, preserving, and studying the organisms of each particular group.

Fresh-water biology is comparatively a new field of study, and of Europe alone can it be said that the information is adequate to outline a picture of the life in fresh water. Records show conspicuously the uniformity of fresh-water life on the surface of the globe, and many of the forms discussed and figured in the pages of this book are identical with those occurring in Europe, and many more are closely related species. And this uniformity extends beyond the continents of Europe and North America, and is found to extend even to the oceanic islands. As a striking illustration of this geographical uniformity we may mention the researches of the late James Murray, biologist of the Shackleton Expedition, in which he records the occurrence of Rotifera known in Britain in the Antarctic lakes that are frozen solid for many months, and often for several years. The present writer has had a living fresh-water fauna under observation from material obtained from the Green Lake, 16,000 ft., in the Himalayas, in which the organisms were well-known forms of British pond-life.

The illustrations, which are very numerous, are mostly new, and in many instances specially drawn by the authors for their individual chapters. The authors, one and all, are to be congratulated on the production of such a comprehensive work, and the publishers for the presentation of it in such an attractive form.

Aquatic Microscopy for Beginners, or Common Objects from Ponds and Ditches. By Dr. Alfred C. Stokes. 4th edition, revised and enlarged. $5\frac{1}{4}$ in. × $7\frac{1}{2}$ in., ix. + 324 pp., 198 figs. in text (New York: John Wiley & Sons, Inc. [London: Chapman & Hall, Ltd.], 1918. 10*s*. 6*d*. net.)

That the above work has now reached its fourth and enlarged edition is an indication that it has served the useful purpose for which it was intended by the author. In the preparation of this elementary guide to pond-life the needs of the beginner in the use of the microscope have been kept in mind, and little or no use of technical language or strictly scientific description is attempted. For critical work on hydrobiology the larger manuals must be consulted. The introductory chapter (Chapter I) deals with the microscope both simple and compound, the methods of observing and measuring objects, and collecting. The main part of the book is arranged under group headings, such as Desmids, Diatoms, Infusoria, Rotifera, etc., each group being provided with analytical tables. Only the most conspicuous external characters are made use of in these tables, with little regard to scientific classification, and with regard to but one result only—to help the tyro to find the name, at least the generic name, of his specimens. These tables seem a very useful feature of the book, and will doubtless prove helpful to the beginner in working out the commoner objects and those most frequently met with, which are all that can be included in a work of this character.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the 541st Ordinary Meeting of the Club, held on March 11th, 1919, the President, Dr. A. B. Rendle, F.R.S., in the chair, the minutes of the meeting held on February 11th were read and confirmed.

Messrs. Walter Richard Warren and Bertram Hyde Jones were balloted for and duly elected members of the Club; four nomination forms were read for the first time.

The Secretary announced that there would be a Gossip Meeting on March 25th, that at the next Ordinary Meeting on April 8th Dr. Hartridge, Fellow of King's College, Cambridge, would read a paper on "Microscopical Illumination," and that the Kodak Company would exhibit three new light-filters that were likely to be useful for photomicrographic purposes.

Mr. Traviss exhibited and described an incandescent gas lamp that he had made on the principle of the lamp described by Mr. Ashe in his recent paper. In the new lamp the incandescent body is a disc of chalk-like consistency, impaled on a flattened pointed wire. A small gas flame from a finely pointed copper jet, whose distance from the disc can be adjusted, impinges on the disc, which is grainless, and gives an excellent light. The lamp is enclosed in a small metal cylinder to keep away draughts, and mounted on a stand so that the height and angle can be adjusted. The result seems to be perfect, as the difficulty of the unevenness of the mantle-image is entirely overcome; the disc moreover is much more durable than the cylinder of mantle material. One which Mr. Traviss had had running for 800 hours was still in good order.

Mr. Traviss also made some interesting remarks about the "healing" of glass. Sir David Brewster referred to this phenomenon 150 years ago, and Mr. Alan Dick had recently brought it to Mr. Traviss's notice. Mr. Dick had a magnifying glass, mounted in the usual way in a metal ring, which had been cracked. By tightening up the ring the crack had gradually healed up. Mr. Traviss exhibited a piece of glass which had been cracked and then clamped—the crack had healed and was only visible with difficulty, but Mr. Traviss said that it was not quite so strong as before. A hearty vote of thanks was accorded to Mr. Traviss for his interesting exhibit and remarks.

Dr. Rendle then delivered the remainder of his Presidential Address which had been held over from the previous meeting. After recapitulating some of the main points of his address, the President went on to describe the pollination of *Orchis maculata.* As is well known, the pollinia of this orchid are so arranged that they become attached to the head of a bee entering the flower. The stalks then bend over so that when the bee enters another flower the pollinia are pressed against the stigma. This is one of the most perfect devices for ensuring insect pollination. In the bee-orchis there is a similar arrangement; but, although the flower retains a most striking form and coloration, it has lapsed into the habit of self-pollination, the pollinia merely falling from the anther case on to the stigma beneath. These instances are rare in the orchid family, which is a large and widespread one, and although we know little about the pollination of exotic orchids, we may assume that the amazing variety of form and colour is associated with a correlated variety in the type of visiting insect. Dr. Rendle then said that if we supposed all orchids to be extinct except those that were self-pollinating, and all sundews to be extinct except those that had acquired a climbing habit (described in the earlier part of the address), it would be extremely difficult to explain their remarkable adaptations.

Dr. Rendle in conclusion drew attention to a remarkable variation which occurs in some grasses growing under Arctic conditions, where they have no time to ripen their seeds. The plants multiply by means of a form of vegetative reproduction known as "vivipary." The flowers are transformed into green shoots, the inner glumes being metamorphosed into leaves and the inner portion becoming sappy, while the lower part of the axis withers up, and tiny roots are ready to shoot out. These shoots fall to the ground in due course and take root. Some species are found—e.g. *Poa alpina*—in which reproduction is effected sometimes by the ordinary sexual method and sometimes by the vegetative, according to the temperature prevailing at the place where they are growing.

In numerous cases we see that the reason for the adaptation of a plant is obvious, even though it be, so to speak, grafted on to a primary or even secondary adaptation ; but there are large series of forms where we are unable to explain form and structure or colour by any known relationship with environment. Have we here examples of purely indiscriminate variation, or do we merely proclaim our ignorance ? For instance, we can explain the colours of flowers, but so far we cannot fully explain the colours of the larger fungi which exhibit almost as striking a variation, and we must be very careful about drawing conclusions.

Mr. C. D. Soar gave a description of the male and nymph of *Oxus plantaris*, a mite of which previously only the female had been described. The specimens were collected by Mr. G. T. Harris on Dartmoor, and form an interesting addition to the British Hydracarina.

The Secretary read an abstract of a paper by Mr. Geo. West, of Dundee, on *Amphora inflexa*, a rare marine diatom.

The thanks of the meeting were accorded to Messrs. Soar and West, and to the President for the continuation of his interesting address.

At the 542nd Ordinary Meeting of the Club, held on April 8th, 1919, the President, Dr. A. B. Rendle, F.R.S., in the chair, the minutes of the meeting held on March 11th were read and confirmed.

Messrs. F. Stanhope Bilbrough, Hy. Guy Martin, Walter Russell and C. Howard Thomas were balloted for and duly elected members of the Club ; five nominations were read for the first time.

The Secretary announced that the first excursion of the season would take place on Saturday, the 12th inst., at the Royal Botanical Gardens, Regent's Park, the members meeting at the south entrance at 2.30 p.m.

The President announced the death of the Club's librarian, Mr. L. George. The members expressed their regret and their appreciation of Mr. George's services to the Club. The President read a list of those members of the Club who had served with H.M. Forces during the war, and asked the members to inform the Secretary of any other members whose names should be included.

Mr. James Burton read a letter from a correspondent in Burma and distributed to the members a quantity of interesting material that had been kindly sent him. The material consisted of all sorts of insects (chiefly Coleoptera, Hymenoptera and Orthoptera), Myriapoda and a variety of objects of interest to the naturalist, such as a trunk-fish, a flying lizard, showing the membrane supported by long, delicate vertebral spines, some small snake-skins and some very large fish scales. Among the most interesting insects were some large ants armed with three pairs of formidable hooks on the dorsal side. The material was packed with a quantity of dried pond-weed, from which after prolonged soaking in water, pond life might be obtained. Mr. Burton and his correspondent received the hearty thanks of the meeting, and the members took home the material, to examine at their leisure.

Mr. J. H. Pledge exhibited on behalf of Kodak, Limited, three new screens which they have added to their well-known M series. No. 38aM is a blue filter for visual use when great resolving power is required. It has no red transmission. No. 78 is intended to give a daylight effect with metal filament lamps. No. 96 is a neutral tint filter which reduces the intensity of the light without altering the contrast obtained with combinations of colour filters.

Dr. Hartridge being ill and unable to read his paper, the Hon. Secretary, Mr. E. K. Maxwell, contributed a paper entitled "The Amateur Microscopist during Wartime," which he had kindly prepared at very short notice. A series of mycetozoa and zoophyte polyparies which had been collected in France was exhibited under various microscopes.

Mr. Maxwell's delightful account of the evolution of the "Mount-Royal Royal Model" and the doings of the "Royal Society" were received with loud applause, and the members present thoroughly enjoyed the communication. Prof. Cheshire proposed a vote of thanks, which was heartily accorded.

At the 543rd Ordinary Meeting of the Club, held on May 13th 1919, the President, Dr. A. B. Rendle, F.R.S., in the chair, the minutes of the meeting held on April 8th were read and confirmed.

Messrs. F. Darley Bickford, Sydney G. Bills, John A. Jones, Joseph Watson and C. P. Choquette were balloted for and duly elected members of the Club; two nominations were read for the first time.

The Secretary announced that the next excursion would take place on the 24th inst. to Greenford and Hanwell, the members to leave Paddington by the 2.25 train. There would be a Gossip Meeting on May 27th, and the next Ordinary Meeting would be held on June 10th, when Mr. Martin Duncan would give an address. The President spoke of the loss that the Club, in company with other scientific societies, had sustained in the death of Sir Frank Crisp. Sir Frank was a generous donor to the Club's library. The Secretary was directed to send a letter of condolence to Lady Crisp.

Mr. Russell brought for distribution a quantity of seeds of *Collomia coccinea.* If a small part of the seed coat be put on a slip under the microscope and allowed to come into contact with a drop of water, remarkable hygroscopic movements take place. The President explained that this was due to mucilaginous degeneration in strips. Mr. N. E. Brown recommended cutting a thin section of the seed rather than cutting off a fragment. The thanks of the meeting were accorded to Mr. Russell.

The Secretary read three short notes from Mr. E. M. Nelson. The first dealt with some of the previous occupants of 20, Hanover Square, at which house the Q.M.C. has met for some years. The second reminded members that pollen polarises, and that when polarised light is used the pollen should be examined dry. The third drew attention to the importance of accurately focusing both halves of the Greenhough binocular microscope. When there is much difference between the focus of one of the observer's eyes and the other, an arrangement for independent focusing is desirable, and when the adjustment for interpupillary distance is made by twisting the boxes containing the Porro prisms, great care must be taken that they are each moved the same distance; otherwise a difference of focus will be introduced. The difficulty may be overcome by a suitable arrangement of cogwheels preventing the boxes from moving independently, or two marks may be made in alignment when the boxes are in the correct position for the observer. Dr. Rendle, in proposing a vote of thanks to Mr. Nelson for his communications, drew attention to the remarkable variation in pollen grains, and recommended members to study them. Dr. Hartridge was then called upon to read his paper on "Microscopical Illumination." Dr. Hartridge said that the experiments described were 8 or 9 years old, and that his conclusions to some extent had been anticipated by Mr. Ainslie, with whom he was in close agreement, in a paper read before the Photomicrographic Society. The theory of microscopic vision held at first by the majority of microscopists was Fraunhofer's, further elaborated by Airy and Helmholtz. This theory stated that the image consisted of antipoints surrounded by systems of rings, and the object was regarded as behaving as if self-luminous. Critical illumination originated with the desire to use the substage condenser under the best possible conditions, the luminosity being greatest when the light was focused on the object. There were others who used oblique light and hollow cones which appeared to give better images of diatom structure with the objectives then available, especially for photography. This latter school received Abbe's theory with acclamation as the last word against their rivals who believed in the Fraunhofer theory, and so a violent controversy began. A few months later Dr. Spitta published his book not only supporting whole-heartedly the principle of critical illumination, but strongly inclining to the theory of Abbe. Dr. Spitta reconciled the two views by pointing out that Nelson's solid cone was nothing more than a number of narrow Abbe beams placed side by side, and that the diffracted beams could be shown to accompany the direct beam through the upper lenses of the objective. Dr. Spitta's views were not coincident with those of his contemporaries, and different interpretations were possible of Abbe's scrappily published theories. Dr. Hartridge criticised the statement that the chief difference between the rival theories of microscopic vision is that Fraunhofer starts from the object (regarding it as self-luminous), while Abbe starts from the source of light. He advanced evidence to support the view that the "source" of Abbe's theory is usually a virtual source placed at infinity of such dimensions that the train of plane waves illuminating the object appears to be proceeding from it. After considering microscopical illumination from the point of view of the Abbe theory, Dr. Hartridge went on to examine the position of critical illumination which is obtained when the image of the source corresponds point for point with the object, and therefore logically requires the use of a condenser as perfectly corrected as the objective. He reached the conclusion that the ideals of critical illumination appeared to have no justification on the basis of the Abbe theory; that its ideals were not realised, as diffraction spectra are formed in the upper focal plane of the objective; and that, owing to the inevitable presence of diffraction effects, they were unrealisable. The success of critical illumination appeared in Dr. Hartridge's opinion to be due to its failure to achieve its ideals, and that it had survived because of its imperfections. The supposed superiority of critical illumination having been shown to be illusory, Dr. Hartridge investigated some other methods which appeared promising with a view to finding out if any were equal to it in practice. The following three methods were compared by experiment:

(1) Critical illumination in which an image of the illuminant is focused on to the object slide.

(2) The method in which an image of the illuminant is focused into the lower focal plane of the condenser by means of a bull's-eye.

(3) Sir A. E. Wright's method, in which a piece of opal glass is placed at the lower focal plane of the condenser and illuminated from behind.

The following tests were applied: (1) The resolution of a grating of 14,000 to the inch with a 40-mm. objective. (2) The resolution of *P. angulatum* (40,000 lines or dots to the inch) with a 4-mm. objective of N.A. 0·95. (3) The resolution of *A. pellucida* into lines and dots (100,000 lines to the inch) with an apochromat of N.A. 1·4. In the first two cases a Davis shutter was used behind the objective, and this and the substage diaphragm were closed until resolution began to break down in some parts of the field. The apparatus was arranged so that the change of illumination could be rapidly made without altering the adjustment. No alteration whatever in resolving power could be detected when this was done. Dr. Hartridge then discussed the various advantages and disadvantages of the three methods. The chief disadvantage of critical illumination appears to be that it is almost impossible to obtain uniform illumination of the object, an essential feature for photography, and that it is difficult to restrict the illumination to that portion of the field corresponding to the photographic plate. The second method does not possess these disadvantages, for the illumination of the field is uniform, and may be restricted by means of a diaphragm. But, as Ainslie points out, it has the disadvantage that the aperture of the substage condenser is usually more brilliantly lit at its centre than at its edges, so that with a solid cone coarse details, since they do not require rays of such great N.A., are represented more brilliantly than fine details. This difficulty may be almost eliminated, Dr. Hartridge said, by putting a slip of finely-ground glass between the iris and the bull's-eye; but some light is lost by doing this. The third method has the advantage of simplicity, but Dr. Hartridge thought that as compared with the other two the image was a shade more milky owing to the presence of scattered light.

Dr. Hartridge has applied to his microscope a fourth method of illumination which is a combination of the second and third. An auxiliary lens is mounted below the iris of the immersion condenser, so that the source of light may be placed at $1\frac{1}{2}$ in. away without spherical aberration. At this point a centring iris diaphragm is attached to the dovetail slide in place of the mirror, and below it is a slip of flashed opal glass illuminated from behind by a small Osram lamp. The light-source is therefore attached to the microscope, and with the iris of the illuminant open a large uniform light is available for low powers, whereas by closing it the illuminated part of the field may be restricted for high-power work. The intensity may if necessary be controlled by means of a simple adjustable resistance.

Dr. Hartridge received a very hearty vote of thanks for his valuable communication.

At the 544th Ordinary Meeting of the Club, held on June 10th, 1919, the President, Dr. A. B. Rendle, F.R.S., in the chair, the minutes of the meeting held on May 13th were read and confirmed.

Messrs. Leonard F. Lawson and H. Alfred Dodd were balloted for and duly elected members of the Club; three nominations were read for the first time.

The President said that the difficult question of the Club's new premises had not yet been definitely settled, but that he hoped it would be possible to make an announcement at the next Gossip Meeting, which would be held at 20, Hanover Square, on June 24th. After that Gossip Meetings would be held as usual through the summer, on the second and fourth Tuesdays of each month, at a place to be announced, and the next Ordinary Meeting would be held on October 14th.

The Secretary read a note from Mr. Nelson recording the fact that he had observed differential staining in the flagella of some minute bacteria—one flagellum being blue and one red in the same bacterium. He had also observed the division of the same bacteria, but with great difficulty. A vote of thanks was accorded to Mr. Nelson for his note.

The President then called on Mr. F. Martin Duncan to give his lecture, entitled "Studies in Marine Zoology." The lecturer apologised for having nothing new to bring before the Club. Marine biological research has been at a stand-still during the war, and the habit of keeping aquaria has almost died out. Mr. Martin Duncan hoped that the study of marine life would be revived. With the aid of lantern slides he then proceeded to describe the boat and some of the collecting apparatus used by the Plymouth Marine Biological station. The boat is broad and by no means luxurious to travel in, as Mr. Duncan's photographs showed. On board are tanks aerated by jets of water, in which the fish and other large captures are stored. Photographs were shown of the winding gear and beam trawl; the trawl is similar to those used commercially, but smaller. The net is pulled along, and the fish swim into the bag, or "cod end." In commercial trawling the size of the mesh is so small that numbers of immature fish are caught, and 96 to 98 per cent. of these are dead either from the weight of heavier fish pressing on them or from exposure to the air before the useful fish have been sorted out and they are thrown back into the sea. The great wastage which thus takes place can only be stopped by legislature controlling the size of the mesh at the cod-end of the trawl, and this is urgently necessary. Photographs of other collecting nets were shown—a conical dredge and a tow-net with a can at the bottom—in which the catch collects. The lecturer said that they also had nets which could be opened when desired and subsequently closed, so that dredging could be started and finished at any given depth.

The scarcity of fish during the war was stated to be partially due to the over-fishing which had taken place previously, and not entirely to submarines. It may possibly be better now, but without legislation the inshore fisheries will again be depleted. Experiments have been made with a view to finding a way of improving the fishing in the case of plaice. The breeding places of these fish are inshore, and between the Yorkshire and Lincolnshire coasts and the Dogger Bank is a deep valley which the fish do not cross until they are 10 or 11 inches long. It was found that by transplanting 10-in. fish that had been marked from the crowded breeding grounds to the better feeding places on the Dogger Bank, and comparing them with marked fish of the same size left in the nurseries, in the course of nine months the transplanted specimens had increased 64 per cent. in length and 360 per cent. in weight, as against 16 per cent. increase in length and 59 per cent. in weight of the non-transplanted fish. The fishermen took considerable interest in the experiments, but made the objection that if the method were adopted there was nothing to prevent fishermen from other countries bordering the North Sea reaping the benefit of their work.

Mr. Martin Duncan then gave a brief account of the development of a flat-fish, taking the flounder as an example. The young fish is at first round and symmetrical, and lives in warm, shallow water. Eventually it settles down, in the case of the plaice, on its left side, and changes begin to take place. The body begins to flatten, the left eye migrates until it almost touches the other, the mouth is pulled to one side and the body becomes pigmented on the right or upper side while the other remains white. If the fish are kept in a glass-bottomed tank with a mirror under it, both sides become pigmented. The monk or angel fish and the rays are true symmetrical flat-fish. Their pigmentation shows remarkable variation, according to the colouring of the sea bottom where they live.

Parental care is not much shown by fishes, but the pipe fishes, to which family the sea-horses belong, are an exception. The male has an incubatory pouch in which the young fish live, and when they come out he protects them so far as he can from danger.

The lecturer then described the two most accurate means of determining the age of fish. If an otolith be examined against a dark-background, it will be seen to consist of alternating dense and semi-transparent rings. The dense part is the spring and summer growth when food is plentiful, and the less dense the winter growth, when in some cases the fish feeds very little, or even for a week or two ceases to feed. The age is found by counting these rings of seasonal growth. Scales may be used in the same way, but they are apt to be damaged and abraded, so that the rings are more difficult to count. Photographs of various marine worms were next shown, including the lug-worm, which is used as bait, and the sea-mouse, which is much eaten by cod-fish, in spite of its bristles. Mr. Martin Duncan had investigated the movements of the legs of the many-footed worms in walking by means of cinematograph pictures. Photographs of several tube-building worms were shown. Various materials are used, and each piece is passed to the mouth in the *Lanice conchelegia* before being placed in position. Owing to the difficulty of obtaining cocaine for narcotising, the lecturer had tried menthol crystals, which he had scattered on the surface of the water containing the creatures required to be narcotised. In the case of sea anemones the method was successful, but slow, taking twelve to twenty-four hours before they could be plunged into the killing fluid. Photographs were shown of some hydrozoa, and a very fine photograph of some living sea-anemones. The next slides were of star-fish; one showed how new rays are grown by a mutilated individual, and another showed how the starfish opens oysters. The starfish is able to exert a steady pull for five hours if necessary, and the oyster is unable to withstand it, although it can resist a sudden force of twelve pounds. Pictures of echinoderms and holothurians followed, and then a series of lobsters and crayfish and their larvae. The lecturer stated that if a lobster is stroked gently along the back twenty or thirty times it becomes inert, but he was not able to explain the phenomenon. The last slides were of squids and octopuses. Several of them showed how quickly these creatures are able to change their colour to agree with the background. A vote of thanks to Mr. Martin Duncan was passed by acclamation.

OBITUARY NOTICES.

JOHN HOPKINSON, F.L.S., F.Z.S., F.G.S., F.R.M.S.,

Secretary of the Ray Society.

(1844—1919.)

It is with great regret we have to record the death of Mr. John Hopkinson, which took place suddenly from heart failure on the morning of July 5th, at his home in Watford. He was in his 74th year.

Born at Leeds in 1844, he came south while still young, residing for the greater part of his life in Hertfordshire, first at St. Albans, and afterwards at "Weetwood," near Watford, the home of his grandfather. He was engaged in business in London as a partner in the well-known firm of J. and J. Hopkinson, piano-manufacturers.

As an indefatigable worker in the pursuit of natural history, and as a promoter of its interests in many and varied ways, one would find difficulty in naming his equal. It is so far back as 1875 that Mr. Hopkinson founded, in conjunction with the late Dr. A. Brett, the Watford (now Hertfordshire) Natural History Society, and the eighteen volumes of Transactions emphasise the zeal with which he laboured; his own contributions are numerous, and the whole series has been issued under his painstaking editorial care. The Herts County Museum at St. Albans arose from his proposal, and he was the originator (1880) of the annual conference of delegates from provincial scientific societies held in connection with the British Association.

Perhaps his most important work in the interests of natural history was as Secretary of the Ray Society. He held this position for fifteen years, and during that period the monographs that appeared were issued under his editorial care. In addition, the preparation of valuable bibliographies to the volumes was undertaken by him, and only those who came intimately in contact with him realised his unwearied industry in securing accuracy and completeness in this branch of work.

He published in 1913 a *Bibliography of the Tunicata*, and was part author with J. Cash and G. H. Wailes of a monograph on *British Fresh-water Rhizopoda* for the 4th vol. of which he prepared a bibliography. To the *Transactions of the Herts Natural History Society* he contributed most useful annual reports from 1876 onwards, on the meteorology of the county embodying a large number of phenological observations. These tables were elaborated by him from the various recorders in all parts of the county. As a Fellow of many scientific societies, he came in contact with a wide circle of friends engaged in kindred pursuits, and all can certainly testify to their gaining by that contact, both in the knowledge and assistance freely given by him, and in the appreciation of an urbane and courteous personality.

Mr. Hopkinson became F.R.M.S. in 1867, and was elected F.L.S. in 1875; he served on the Council from 1908 to 1911. He joined the Q.M.C. in 1904.

GEORGE STEPHEN WEST, M.A., D.Sc., F.L.S.,

Mason Professor of Botany in the University of Birmingham.

(1876—1919.)

George West was the younger of two brothers, sons of William West, of Bradford (died 1914), a first-rate British botanist, with a knowledge both of flowering plants and cryptogams. Both sons inherited their father's love for field botany. The elder, William, died in 1901, in India, where he had gone to take up a botanical appointment. George, like his brother, was educated at the Royal College of Science, and at St. John's College, Cambridge, where he was elected to the Hutchinson Research Studentship. He left Cambridge to become Lecturer in Natural History at the Royal Agricultural College, Cirencester, and in 1906 became Lecturer in Botany at Birmingham University, under Prof. Hillhouse. On Hillhouse's retirement in 1909 West became Professor of Botany, and in 1916 was appointed to the newly established Mason Professorship. West was a successful teacher, and the Botanical Department at Birmingham developed considerably under his guidance. His death on August 7th, after a brief illness following on a period of indifferent health for some years, is a much-to-be-regretted termination of a busy, helpful and fruitful career.

West was early attracted to the study of the Fresh-water Algae, doubtless influenced by his father, with whom he co-operated in investigations on the Desmids. For some years before his death he was the leading British expert on the Fresh-water Algae, and collections from all parts of the world were entrusted to him for investigation, and supplied the material for numerous careful systematic papers published in the *Journal of Botany*, the *Journal* and *Transactions of the Linnean Society*, and elsewhere. His account of the British Desmids occupies four volumes of the Ray Society's publications, and a fifth volume was in preparation at the time of his death. Other important publications are his *Treatise on British Fresh-water Algae* (1904), and the volume on the *Myxophyceae, Peridinieae, Bacillarieae, and Chlorophyceae* (1916), the first of the series of Cambridge Botanical Handbooks.

West was an excellent draughtsman, and has left a large series of drawings of Fresh-water Algae, both British and foreign ; these are bequeathed to the Department of Botany of the British Museum ; his library and specimens will find a home in his own Department at Birmingham University. Fortunately there are pupils, trained in his careful methods of investigation, to carry on his work, and it is hoped that one of these, Dr. Nellie Carter, may be able to complete the work on British Desmids under the auspices of the Ray Society.

Members of the Quekett Club will recall an interesting communication by Prof. West on two African species of Volvox, read at the meeting on April 9th, 1918 ; this was in continuation of a paper appearing in the *Journal*, xi. pp. 99–104. The election of Prof. West as an Honorary Member of the Club took place at the meeting on October 8th, 1918.

A. B. R.

Table for the Conversion of English and Metrical Linear Measures; Yard at 62° F. and Metre at 0° C.

1 ÷	mm.	1 ÷	μ	1 ÷	μ	1 ÷	μ	1 ÷	μ
2	12·70	27	941	53	479	79	322	125	203
3	8·47	28	907	54	470	80	317	130	195
4	6·35	29	876	55	462	81	314	135	188
5	5·08	30	847	56	454	82	310	140	181
6	4·23	31	819	57	446	83	306	145	175
7	3·63	32	794	58	438	84	302	150	169
8	3·17	33	770	59	431	85	299	155	164
9	2·82	34	747	60	423	86	295	160	159
10	2·54	35	726	61	416	87	292	165	154
11	2·31	36	706	62	410	88	289	170	149
12	2·12	37	686	63	403	89	285	175	145
13	1·95	38	668	64	397	90	282	180	141
14	1·81	39	651	65	391	91	279	185	137
15	1·69	40	635	66	385	92	276	190	134
16	1·59	41	620	67	379	93	273	195	130
17	1·49	42	605	68	374	94	270	200	127
18	1·41	43	591	69	368	95	267	205	124
19	1·34	44	577	70	363	96	265	210	121
20	1·27	45	564	71	358	97	262	215	118
21	1·21	46	552	72	353	98	259	220	115
22	1·15	47	540	73	348	99	257	225	113
23	1 10	48	529	74	343	100	254	230	110
24	1·06	49	518	75	339	105	242	235	108
25	1·02	50	508	76	334	110	231	240	106
	μ	51	498	77	330	115	221	245	104
26	977	52	488	78	326	120	212	250	102

As the measurements of many microscopical objects are given in fractions of an inch in English literature, and in metrical measure in foreign works, the above table has been drawn up to facilitate comparison. Its use is obvious. Examples: 1/7th inch = 3·63 mm., 1/58th inch = 438 μ, or ·438 mm. For fractions smaller than 1/250th inch that portion of the table between the figures 26 and 99 may be used by cutting off the last figure for hundredths, and the two last figures for thousandths. Examples: 1/270th inch = 94·1 μ, or ·0941 mm.; 1/7900th inch = 3·22 μ, or ·00322 mm. When that portion of the table between the figures 100 and 250 is used it is only necessary to cut off the last figure for thousandths. and the two last figures for ten thousandths. Examples: 1/1350th inch = 18·8 μ, or ·0188 mm., 1/16500th inch = 1·54 μ, or ·00154 mm. The conversion of millimetres into fractions of an inch is performed in the same smanner; thus, 529 μ or ·529 mm. = 1/48th inch; 39·7 μ or ·0397 mm. = 1/640th inch; 2·62 μ or ·00262 mm. = 1/9700th inch; 1·04 μ or ·00104 mm. = 1/24500th inch; ·977 μ or ·000977 mm. = 1/26000th inch, and so on.—E. M. N.

HYDRACARINA: THE GENUS EYLAIS *LATR.*

By Charles D. Soar, F.L.S., F.R.M.S., and W. Williamson, F.R.S.E., F.L.S.

(*Read January 13th*, 1920.)

Plate 3.

The genus Eylais * was established by Latreille in 1796, and is notable by reason of the structure of the capitulum and epimera and of the eye plate, which consists of a pair of eye capsules united by an intercapsular bridge as well as by its pronounced disposition to pass into varietal forms. Several widely distributed forms, though usually recorded as distinct, have been suspected for long to be either merely varieties or stages in the development of one species. The difficulty of obtaining suitable material for working out the life-history adds greatly to the complexity of the problem, even in normal times. When one recollects C. L. Koch's reputation as a species maker, there is reason to be thankful that the intercapsular bridge was too small a feature to arrest his attention, otherwise succeeding workers might well be baffled in the endeavour to reduce Koch's species to their proper limit.

Apart from its varietal disposition the genus has several well-defined characteristics. The capitulum is short, and on its flattened ventral surface it bears the sucker-like mouth, bordered by a fringe of hairs. The basal portions of the mandibles form a pseudo-capitulum. The paired eyes are in capsules, which are united by a bridge varying with the degree of separation between the capsules. In one or two species the capsules may be separated and the bridge wanting. Considerable prominence,

* An old form of the name omits the y. Piersig, apparently founding on Agassiz, changed the name to Eulais. Later Koenike, unable to find any support for the idea of Greek origin, restored the original name Eylais.

In the glycerine medium used for other genera, Eylais does not behave well, as frequently specimens are found to have become unsuitable for useful work. A thymol solution introduced by Koenike appears to have more satisfactory results.

perhaps too much, has been given in recent years to the varying outline of the bridge between the capsules. The epimera are of a much more delicate structure than is found in other genera. They are for the most part narrow, and are formed of a lattice-work framed by a well-defined ridge. The genus also furnishes some of the largest forms to be met with in the Hydracarina, the type (*E. extendens*) sometimes attaining a length of 5 mm. In order to facilitate the work of those whose studies in variation might lead them to consider its aspects as expressed in Eylais, a list of other recorded species known to us at this date, with appropriate bibliographical references, was prepared, but the economic conditions now prevailing necessitate restriction to species occurring within the Britannic area.[1]

Additions to the British Fauna are indicated thus * and to the Britannic area thus †.

Eylais extendens (Müll.) (Pl. 3, fig. 10).

The body is oval in outline, and is dorso-ventrally compressed. The legs and palpi are a paler red than the skin of the body, which is covered with ridge-like markings. The pores of the dermal glands are very small and are protected by a strong and rather large hair.

The eye capsules are relatively short and broad, and are composed of a coarsely granulated chitin, which appears to be thickened at the edges of the capsules. The intercapsular bridge is short, being about one-third the length of the capsules, and is moderately broad. The anterior margin has a slight concavity in the middle, and the strong process for muscle attachment does not extend beyond the margin. Between each capsule and the process there is a sensory organ, one on each side, furnished with a long and strong bristle. The anterior eye lens is large and stalked, while the posterior lens is of a long ellipsoidal form.

The palpi are not so stout as the segments of the first pair of legs and are less than one-fourth the length of the body. The flexor surface of the first segment is very much shorter than the extensor. The second segment has very few bristles on its extensor surface. The third segment is of about the same length as the second, and has a number of spines on its extensor surface.

[1] It may be possible to publish this list at some future date in the pages of the *Journal*.—Ed.

The distal end of the flexor surface bulges out, and is furnished with ten or more spines, some with a tendency to be pectinate. The fourth segment is about double the length of the third; it is more slender and tapers slightly at the distal end; on its flexor surface there are two longitudinal rows of strong, slightly curved spines. The fifth segment is barely half the length of the fourth; slightly tapered distally, it shows a tendency to curve on the flexor surface and terminates in three short spines.

The sides of the capitulum spread out anteriorly so as to form a broad shoulder where the palpi spring from it; the anterior edge has a moderately deep cut into it. The anterior processes are strong, with their distal ends broadened out. They are directed towards the posterior, but do not go so far as the base of the posterior pair, which are short and broad with their ends broadened out and bluntly rounded. The mouth is almost circular with a broad outer ring. The maxillary plate is almost entirely covered by large pores. The pharynx is broad with the pharyngeal ridge set so far back as to make the metapharyngeal area rather insignificant. The air sacs are slender, slightly inflated and curved at the distal end.

The epimera occupy the anterior half of the ventral surface. The first two pairs are fused together for the greater part of their length, but they are separated a little at the outer extremity. The third and fourth pairs are so hinged together at their inner extremities that they leave a large triangular space between them. The epimera, of which the third pair are the broadest, are built up of a chitinous trellis-work framed by a thick chitinous border.

The legs are relatively short and thin. The first pair may attain a length of 2·6 mm., and the fourth pair 3·4 mm. The fourth pair of legs are without swimming hairs, but are well furnished with pectinate bristles of which the first two pairs of legs also possess a considerable number.

The anus lies near the middle of the ventral surface, and is protected by a thick chitinous ring, while the genital area lies between the first pair of epimera.

Piersig gave some information relative to the life-history in *Zoologica*, xxii., but this must be accepted with some reserve, because at the time several species were grouped under the one name *extendens*, and thus it is quite possible that more than one species may have contributed to what has been published as the life-history of *E. extendens*.

The species has been found in England, near London, and at Folkestone Warren, and in Ireland. It is well distributed over Europe, and has also been recorded from Palestine, Egypt and Portuguese E. Africa.

Eylais hamata Koen. (Pl. 3, fig. 9).

1897. Koenike. *Abh. Natur. Ver. Bremen*, vol. xiv. p. 282, fig. 1.

This species was found originally in Palestine, and was recorded by Koenike as *E. extendens*. Two years later he gave it the name by which it is now known. The intercapsular bridge is distinguished by its extraordinary width, amounting, in the case of a specimen 4·5 mm. in length, to 0·25 mm. The length of the bridge may be about half the length of the capsules. On the inner side of each capsule there is a tactile hair, and between that again and the median point, the anterior margin of the bridge develops on each side into a process. In a marked degree the capsules and bridge suggest the outline of a dumbbell.

The first two segments of the palpi are much wider at the distal than at the proximal extremity, the extensor surface of each being about twice the length of the flexor surface. The third and fourth segments are nearly parallel throughout. The distal flexor surface of the third segment tends, though indistinctly, to bulge out and bears a number of strong bristles, some of which are coarsely pectinate. The inner surface of the fourth segment has a number of irregularly disposed bristles, of which some are pectinate. The fifth segment tapers towards the distal extremity, and ends in a cluster of bristles, so much blunted as to suggest that their extremities have been broken off.

The capitulum is roughly rectangular in outline, the lateral and posterior margins being nearly straight, though the anterior margin arches well forward. The median line of the outer surface is very distinctly keeled. The anterior processes are longer and more slender than those of *extendens*. The posterior processes are very short and bend downwards. The mouth area is unusually large, forming a transverse ellipse which is surrounded by a narrow strip rendered conspicuous by its very large pores.

The air sacs are shorter than the pharynx, which extends considerably beyond the posterior line of the capitulum. The pharyngeal plate is cone-shaped, broad and rounded at its base. The ridge is pushed well back, reducing the metapharynx to a narrow strip with a hook-like projection at each end, giving rise to the specific name.

The process at the inner end of the second pair of epimera is broad and ligulate and is directed posteriorly. That at the end of the fourth pair is also ligulate, and is directed posteriorly like that at the end of the second pair; though rather large, it is stiffened by a strip of chitin, which extends beneath the epimeral plates to the anterior margin of the third pair.

E. hamata is one of the large species, as it may attain a length of 5·5 mm. It has been found in Britain and Ireland, and has further been recorded from Finland, Russia, Macedonia, Palestine, as well as Austria and Germany.

[**E. georgei.**—In 1901, Soar described a new species which he named *E. georgei* (*Science Gossip*, N.S., viii. 48). It differed from *hamata* with its wide and *typically* straight bridge between the capsules in that the bridge was more or less curved. Koenike appears to have been of the opinion that *georgei* and some other wide-bridged species were only varieties of *hamata*, and it is noteworthy that the metapharyngeal hooks of *hamata* appear in most of these other species also. Halbert has noted (*Ann. Nat. Hist.*, Ser. 7, xii. 506) that in the Irish forms of *hamata* the bridge varies from a straight to a more or less bent-back outline. In the specimens of *georgei* examined by me, variation to a more or less marked degree was present. In one, the bridge had become attenuated so as to resemble two long links joined at their inner ends by a small ring, and at the outer ends joined to the capsules by another small ring. The temptation to mark this as a very distinct variety was strong, but, with the fuller knowledge that we now possess of the capacity for variation inherent in Eylais, I think we must consider *georgei* as a synonym of *hamata*.—W. W.]

Eylais mülleri Koen. (Pl. 3, fig. 3).

1897. Koenike. *Abh. Natur. Ver. Bremen*, vol. xiv. p. 282.

In this species the eye capsules are rather wider apart than in *E. extendens*, but the intercapsular bridge is of about the same length. The posterior margin varies from being rounded to nearly straight, while the anterior margin stretches right across from the anterior ends of the capsules. In the middle there is a deep incision with a tapered process for muscle attachment projecting well over it. On each side of the process there is a moderate sized tubercle with a long bristle. The postero-lateral region of the capsules bulges out very much, and gives the impression of a deeper depression than usual in the outer edges.

The palpi are about 1 mm. in length. The distal flexor surface of the third segment is very much distended, and more densely clothed with pectinate spines than *E. extendens*. Distributed over the extensor surface numerous bristles are to be found. The flexor surface of the fourth segment has two rows of spines with a distal group of pectinate spines. The fifth segment at its distal end is rather more tapered than *E. extendens*.

Compared with the type, the capitulum is not so stout in its general structure. Its processes are of a more slender form, with the anterior pair decidedly longer, reaching nearly as far as the distal extremity of the posterior pair. The anterior edge of the maxillary plate lies well forward, with a more or less angular indentation in the middle. Except along the posterior margin, the maxillary plate is covered with pores. The ridge on the pharynx is very strong and protrudes at the edges, so as to appear like papillae. The metapharynx is large and extends beyond the extremities of the posterior processes. The mouth area is rather smaller than that of *E. extendens*.

Only the male, which may attain a length of 3·5 mm., appears to be known. Its occurrence has been recorded for England and Scotland, and on the Continent in Hungary and Austria, Germany, Denmark and Norway.

Eylais triarcuata Piers. (Pl. 3, fig. 16).

1899. Piersig. *Zool. Anz.*, vol. xxii. p. 66, fig. 7.

The palpi and the intercapsular bridge in this form are rather variable, and the opinion has even been expressed that it is only a varietal form of *E. extendens*.

The eye capsules are reniform, measuring about 0·27 mm. in length. The anterior eyes have a short stalk, while the posterior pair are of the usual form. The length of the intercapsular bridge is about one-third that of the capsule. The presence of two lateral tubercles and a larger, more or less, protruding median process gives to the anterior margin the appearance of three arches, whence the specific name. The posterior margin may be evenly rounded or may have a truncated appearance. The edges of the tubercles are rather thick.

The palpi may attain a length of over 0·8 mm. The distal end of the flexor surface of the third segment is swollen, and towards the inner surface there may be about fifteen short spines, some of which are bipectinate. The bristles on the fourth segment tend to display irregularity in their arrangement. The extensor surface has two or three long bristles. The fifth segment has a large number of long and short bristles.

The anterior processes of the capitulum are directed obliquely backwards in an upward direction ; the posterior processes are moderately developed. The pharynx extends posteriorly beyond the extremity of the posterior process, and is widest about the middle. The pharyngeal ridge is broad and the metapharyngeal area is long and rounded posteriorly. The air sacs extend beyond the posterior end of the pharynx.

The epimera and legs are similar to those of *extendens*. So far, only the female is known definitely. The length varies from 3 to 5 mm. It has been found near Dublin, and in some other parts of Ireland, and is also recorded from Italy, Bohemia, Hungary, Germany, Russia, Sweden and Finland. It was recently recorded from S. Devon, and material taken at Norfolk Broads, Mill Hill and in Suffolk and Kent appears to be referable to this species.

Eylais rimosa Piers. (Pl. 3, fig. 4).

1899. Piersig. *Zool. Anz.*, vol. xxii. p. 65, fig. 6.

This is one of the moderately large species, the length ranging from 3 to 3·5 mm.

The anterior edge of the intercapsular bridge has two rounded projecting protuberances, each with a long hair. Between each of the protuberances the bridge is cleft as far as the process for muscle attachment. The posterior margin is deeply recessed rather beyond the middle of the capsules. The anterior eye lens is of medium size and is set on a short stalk.

The palpi are about 0·90 mm. in length. The distal portion of the flexor surface of the third segment bulges out, and is furnished with about a dozen spines, of which three or four are slightly pectinate. The flexor surface of the fourth segment has about five spines on the outer edge. Inwards there are five spines and five pectinate bristles, of which four are distal. The fifth segment has four short bristles at the end, and on each side there are two short spines.

The anterior edge of the capitulum is emarginate. The portion of the capitulum lying posterior to the almost circular mouth is covered with numerous angular pores. The antero-lateral processes are of normal form and pass obliquely into the body. The postero-lateral processes are not very thick, but they are broadened at the ends. The pharynx narrows slightly in front of the pharyngeal ridge, but it is well rounded posteriorly.

E. rimosa has been found at Lowestoft and at Woking and Epping Forest. It has also been recorded from Switzerland, Russia, Italy, Finland, Austria-Hungary and Germany, as well as from Algiers. The life-history is unknown.

Eylais undulosa Koen. (Pl. 3, fig. 11).

1897. Koenike. *Abh. Natur. Ver. Bremen*, vol. xiv. p. 283, fig. 2.

The intercapsular bridge is about the same width as that of *E. extendens* and about half the length of the capsules themselves. The anterior margin is wavy, while the posterior is almost straight. Nearer to the anterior margin, and about equidistant from each other and from the eye capsules, there are two moderately long bristles. The anterior eye lenses are each on a stalk, and the posterior lenses are of an elongate ellipsoidal form.

The palpi are about 0·8 mm. long. The flexor surface of the third segment passes gradually into a strongly developed anterior prominence, having about a dozen spine-like bristles on it. The flexor surface of the fourth segment bulges out in its anterior portion, and has an inner row of three bristles and an outer row of six or seven, and with the latter there is to be noted a short curved bristle set upon a small papilla and two small pectinate hairs near the two anterior bristles. The anterior bristle of the inner row has numerous small pectinate hairs about it.

The capitulum agrees closely with that of *E. mülleri* Koen.

The anterior pair of processes are shorter and directed rather more towards the front. The posterior pair are stouter than in the case of *E. mülleri.* The fringed margin of the mouth is not quite circular, the anterior portion showing three blunt angles. The anterior edge of the capitulum has a small piece cut out. A small area close behind the mouth has a number of coarse pores. The pharynx extends a little beyond the capitulum, and has some resemblance to that of *E. mülleri.*

E. undulosa attains a length of 2·7 mm. It is, so far as recorded, not a widely distributed species, having only been recorded from the Royal Canal near Dublin and from Russia and Germany. The sex has not been determined and the life-history is unknown.

Eylais unisinuata Croneberg. (Pl. 3, fig. 5).

1902. Croneberg. *Bull. Soc. Nat. Moscow,* p. 98, plate xii. fig. 9, *a–c.*

1903. Halbert. *Ann. Mag. Nat. Hist.,* Ser. 7, vol. xii. pp. 511–512, fig. 7.

Croneberg's original description is somewhat meagre, but Halbert has supplemented this from material taken in the River Corrib near Galway, which he has referred to this species. From the Russian description, we learn that the eye capsules are united anteriorly by a narrow bridge, having a length equal to about half that of the capsules. The anterior margin is almost straight between the anterior extremities of the capsules and has only an indistinct notch in the middle; on each side of the latter there is a short bristle. Beneath the notch, and pointing anteriorly downwards into the body, is a process for muscle attachment. The posterior margin of the bridge is short and straight, and forms the base of a deep bay, separating the posterior halves of the two capsules. The Irish material appears to be very variable so far as the intercapsular bridge is concerned. The process for muscle attachment is large and semicircular, and extends as far as or even beyond the anterior margin of the plate. The inner and outer margins of the capsules are decidedly sinuate.

Croneberg describes the palpi as in some measure resembling those of *E. emarginata* Piers. The bristles on the inner edge of the second segment are not pectinate. The anterior inner surface of the third segment is strongly developed and has numerous pectinate bristles. The fourth segment has an outer row of eight spines with two pectinate bristles at the distal end, and an inner row of seven spines and four pectinate bristles. Apparently the Russian material is subject to a considerable degree of variability in respect to the number and position of these bristles. In the Irish specimens, the palpi, which may attain a length of 1·40 mm., have the second segment with four spines towards the inner end of the distal margin. The third segment has the inner corner moderately developed with 8 or 9 spines, some being pectinate.

The capitulum is rather deeply emarginate distally, and is curved outwards at the centre. The lateral processes are directed downwards. The large pores on the capitulum are well distributed especially in the central area.

E. unisinuata attains a length of 3–4 mm. Sex not determined and life-history unknown.

* **Eylais bicornuta** Halb. (Pl. 3, fig. 19).

1904. Halbert. *Irish Nat.*, vol. xiii. p. 200, plate x. figs. 1–2.

So far this species has only been recorded from Lough Gill in Ireland, but material taken in England at Reigate and Kirton-in-Lindsey and in Derbyshire can be referred to *E. bicornuta.*

The intercapsular bridge is long, but it is narrower than in *E. gigas* Piers., to which it has some affinity. The processes on the anterior margin are much longer, and end bluntly; they extend directly from the margin with a deep bay between them, and are not surrounded anteriorly as in *gigas*. The posterior emargination is about one-third the length of the bridge, which has a rounded prominence serving for muscle attachment near the middle.

The palpi are about 1·42 mm. in length, and resemble those of *E. infundibulifera* Koen. The inner corner of the third segment is moderately developed and has numerous long strong spines with a few pectinate ones. The proximal inner surface of the fourth segment has eight or nine long spines in a row, and to correspond with these on the outer surface there are about seven.

The pharynx extends well beyond the lateral processes of the capitulum. The anterior processes have a sort of angular projection near the centre of their posterior margin. The mandibles are about 0·46 mm. in length.

Eylais celtica Halb. (Pl. 3, fig. 12).

1903. Halbert. *Ann. Nat. Hist.*, Ser. 7, vol. xii. p. 514, fig. 10.
1911. *P. Irish Ac.*, vol. xxxi. (39 i) p. 8, pl. 1, fig. 4.

This Irish species, found in Ballynahinch Lake in Connemara, measures about 4 mm. in length, and has a relatively large epimeral area.

The whole eye plate is very large, the intercapsular bridge being almost as long as the capsules themselves. The posterior margin of the bridge is slightly concave, while the anterior margin is produced into a blunt median point. The eye capsules are much wider in their anterior portion than in the posterior, while the inner and outer margins are sinuate. The hair pores on the inner anterior corner of the capsules are slightly behind the narrow chitinous strip between the median process for muscle attachment and the eye capsules.

The palpi resemble those of *E. infundibulifera.* The second segment has four or five spines on the inner distal margin, and four pectinate spines at the distal inner corner. The third segment has the distal portion of the flexor surface moderately developed; there are about twenty long spines, many of which are pectinate. The fourth segment has the proximal half of the inner surface crowded with long bristles and the outer surface with a row of nine or ten similar long ones.

The capitulum measures about 0·55 mm. and also resembles that of *E. infundibulifera.* The postero-lateral processes are short and curved inwards at their apices. The pharynx is long and narrow, and the air sacs reach near to the pharyngeal ridge.

Eylais discreta Koen. (Pl. 3, fig. 13).

1897. Koenike. *Abh. Natur. Ver. Bremen*, vol. xiv. p. 286, fig. 6.

The intercapsular bridge is short and broad. Its anterior edge extends only very slightly beyond the eye capsules, and is more or less weakly toothed. The posterior edge bounds a deep V-shaped bay which extends in between the capsules for about half their length.

The palpi are about 1·20 mm. in length, and are stout, resembling *E. setosa* in its bristle armature. The third segment is almost devoid of any protuberance at the anterior end of its flexor surface, but is well equipped with bristles, which are distinctly pectinate though somewhat longer than those of *E. setosa.* The proximal half of the flexor surface of the fourth segment is not chitinised like the rest of the segment. The inner surface has a row of eight spines, and about an equal number of short pectinate bristles. The outer surface has seven longer spines. Distally the fifth segment has a number of short claws.

Like the preceding species the capitulum bears some resemblance to that of *E. infundibulifera.* The anterior edge is slightly emarginate with corners rounded. The mouth is circular and of medium size. Except for a small strip at its posterior end, the surface of the capitulum is covered with large pores. The antero-lateral processes are short, and not broadened out at their extremities. The posterior pair are long, with their extremities bent upwards and inwards. The pharynx extends only slightly beyond the latter and is weakly chitinised at its posterior end, where it has a width about equal to that at the middle. The air sacs are not so long as the pharynx and are thin. The mandibles have the end of their basal member broadly rounded, with a small blunt protuberance at the posterior end of the flexor surface, and a deep depression on the extensor surface near to the anterior end.

The body, which is about 4·50 mm. in length, is oval in outline, and has the anterior margins of its epimera fringed with hairs. The first three pairs of legs are furnished with swimming hairs and range from 2·50 mm. to 3·20 mm. in length. The fourth pair attain a length of 3·50 mm. So far nothing has been recorded as to the male or the life-history.

The species has been found in England at Kew Gardens, and at several localities in Ireland, as well as in Norway and Sweden, Bohemia and Germany.

Eylais discreta var. **stagnalis** Halb. (Pl. 3, fig. 14).

1903. *E. infundibulifera* var. *stagnalis* Halbert. *Ann. Nat. Hist.*, Ser. 7, vol. xii. p. 513.

1911. *E. discreta* var. *stagnalis. P. Irish Ac.*, vol. xxxi. (39 i), p. 5.

This variety measures in the male up to 3 mm. and in the female up to 5 mm., and was first taken near Dublin and later in the "Forth" area (Scotland) and in Berkshire.

The eye plate is large and appears to be subject to considerable variation. The middle of the anterior margin of the intercapsular bridge is drawn out into a narrow irregularly shaped process for muscle attachment. The posterior emargination is broad and deep, and extends nearly as far as the middle of the first pair of eyes. The outer margins of the eye capsules are sinuate, the inner margins more weakly so, while the inner anterior corners are slightly angular.

The palpi have the second segment with nine or ten strong spines on the distal inner margin. Some of these are pectinate. The distal flexor surface of the third segment is only slightly developed, and has about eighteen long spines. The proximal half of the inner surface of the fourth segment has about twenty long spines, and at the distal end there is a row of pectinate spines. The proximal outer surface has seven long bristles. The distal end of the fifth segment has eight or nine short and stout blunt claws.

The capitulum is deeply emarginate distally, the lateral processes being directed outward and downward. The pharynx is relatively narrow and the pharyngeal ridge sinuate.

Eylais soari Piers. (Pl. 3, fig. 1).

1899. Piersig. *Zool. Anz.*, vol. xxii. p. 67, fig. 8.

The eye capsules of this species are united by a moderately long and broad bridge, the anterior margin of which has a deep median bay, which terminates at each end in a rounded process. Each process extends forward almost as far as the anterior edge of the capsules, and has a long hair springing from its centre. The process for muscle attachment is in the form of a rounded boss, sometimes accompanied by a pair of finger-like processes. The capsules are variable in outline and range from a long reniform shape to a shorter or almost round one. From the outer edge of one capsule to the outer edge of another, a breadth of about 0·4 mm. may be attained.

The distal end of the flexor surface of the third segment of the palpi is not very prominent. It is furnished with thirteen to fifteen strong but not very distinctly pectinate spines. On the flexor surface of the fourth segment there are two rows of spines.

The outer row consists of eight smooth, strong spines, the last two being at the distal edge of the segment. The inner row has five spines, and there are also four short pectinate hairs at the distal edge. The palpi range in length from about 1·12 mm. to 1·38 mm.

The anterior edge of the capitulum is moderately arched forward. The lateral edges extend into rather long processes. The anterior processes are very strong and broad distally, and extend beyond the posterior edge of the maxillary plate. The pharynx is very broad and moderately contracted in front of the very distinctive pharyngeal ridge. The metapharyngeal region is relatively small, and scarcely extends beyond the distal end of the posterior processes.

The anterior edge of the first pair of epimera is very slightly sinuate, meeting the almost straight posterior edge at a point. The inner ends of the first and second pairs pass into a long subcutaneous process, with its inner edge a little irregular and terminating anteriorly in a hook-shaped process. The anterior edge of the third pair is turned up slightly at the end, the posterior edge continuing in a broad curve well beyond the fourth pair.

In length *E. soari* may range up to 4·5 mm. At present the male and life-history are unknown.

E. soari is a fairly widely distributed species. In the British Isles, it has been found at Connemara in Ireland, in England at the Norfolk Broads, Barmouth, Oxshot, Mill Hill and Lowestoft, and in Lincolnshire and Surrey, and in Scotland at Oban. It has also been recorded from Turkestan as well as from Belgium, Switzerland, Italy, Sweden, Russia, Hungary, Austria and Germany.

Eylais soari * var. **instabilis** Halb. (Pl. 3, fig. 2).

1903. Halbert. *Ann. Nat. Hist.*, Ser. 7, vol. xii. p. 510, figs. 4–5.

This is an Irish variety which in general comes near to *E. variabilis* Thor, though the capitulum, which measures over all about 0·66 mm., bears some resemblance to that of *E. mülleri* Koen.

In general structure the eyes are of a stouter build than *E.*

soari, the extreme width over the capsules being from 0·45 mm. to 0·48 mm., and their length about 0·25 mm. The intercapsular bridge is rather broader and longer than in the type, with the posterior emargination variable in character, being rounded or more or less angled.

The palpi are stout and are about 1·20 mm. in length. The flexor surface of the third segment is well developed distally, and has from fourteen to eighteen short spines, the innermost ones being weakly pectinate. The fourth segment is also strongly developed with about six long spines, and four or five pectinate ones close to the distal margin. A specimen taken at the Norfolk Broads is referable to this variety.

* **Eylais koenikei** Halb. (Pl. 3, fig. 6).

1903. Halbert. *Ann. Nat. Hist.*, Ser. 7, vol. xxii. p. 507, figs. 2–2*a*.

This species appears to be of a more rotund form than is usual in the genus. The length is about 3 mm.

The intercapsular bridge is subject to some variation in regard to its position at the anterior end of the eye capsules. It is very slender and decreases in width towards the small oval process in the centre of the bridge. Between this and each eye capsule there is a small hair papilla variable as to its position. The capsules are roughly quadrate in outline with large pores. The anterior and outer margins are weakly rounded, while the inner margin is emarginate, bulging out posteriorly.

The palpi are rather long and slender. The second segment has four or five weakly pectinate spines on its distal inner surface. The third segment has seven or eight short, stout spines also on its distal inner surface, one or two of these being pectinate. The fourth segment has about ten spines towards its inner surface. On the outer side there are seven long bristles.

The capitulum is about 0·6 mm. in length. Its lateral and posterior margins are moderately curved, the latter outwards in the centre. The pharynx is broad, being very much distended in its anterior portion.

E. koenikei has been taken at Ardfry, co. Galway, and Lough Gullion, co. Armagh, and at the Norfolk Broads.

* **Eylais similis** Thon. (Pl. 3, fig. 15).

1899. Karl Thon. *Zool. Anz.*, vol. xxii. p. 446, fig. 2.

This species is apparently capable of considerable variation in so far as the eye plate is concerned, though there is a measure of resemblance to that of *E. rimosa.* The capsules here are broader and much straighter at the sides, while the intercapsular bridge is narrower and slightly longer. The posterior edge has a deep recess, varying from a more or less acuminate to a rounded form, and reaches to about the middle of the capsules. The anterior edge is sinuate with a moderately deep median incision. On each side of this incision there is a protuberance with a long hair rising from it and a well-defined ring. The process serving for muscle attachment is quite prominent.

The palpi are about 0·80 mm. in length, and not so stout as those of *E. extendens.* The second segment has about eight pectinate bristles at its distal end. The third segment has the distal end of the flexor surface more or less well developed, and carries about twelve short and broad pectinate spines. The extensor surface has four longer bristles. The fourth segment is about as thick and twice as long as the third segment. Its flexor surface carries nine or ten long spines, and at the distal end four or five pectinate bristles. The fifth segment is small, terminating in three or four small claws.

The capitulum bears some resemblance to that of *E. extendens.* Its antero-lateral processes are slender and extend to about the level of the base of the postero-lateral ones, which are fairly long and well separated. Both pairs of processes are broadened out towards their extremities, with the distal end rounded. The pseudo-capitulum is low, and not so broad as the anterior end of the capitulum. In its lower portion the pharynx is as broad as the capitulum, tapering up towards the mouth. The meta-pharyngeal ridge is so close to the distal end as to leave the meta-pharynx reduced to a narrow strip.

The first pair of the epimera are of nearly equal width, the inner ends tapering abruptly to a blunt point. The second pair are rather wider at the outer extremity than at the inner, where the processes are so spread out as to resemble a foot in outline. The third pair are much increased at the outer end. The fourth pair are nearly triangular, and are attached to the third pair only at the inner end. The processes at the inner end of the third pair are broad, and extend inwards, while those of the fourth pair are slightly narrower and longer and directed towards the posterior.

The legs range from about 1·50 mm. in length in the first pair to about 2·30 mm. in the fourth pair. All the segments are of about equal thickness. The claws are long and slender, while the accessory claws are short and broad.

Surrounding the anus is an irregularly shaped chitinous ring.

This species, which measures about 2·5 mm. in length, has been found in Surrey as well as at Westport, Louisburg and Clare Island in Ireland. Its continental distribution, so far as present information goes, is limited to Bohemia and Hungary.

Eylais symmetrica Halb. (Pl. 3, fig. 7).

1903. Halbert. *Ann. Nat. Hist.*, Ser. 7, vol. xiii. p. 508, fig. 3.

The eye capsules are reniform with large lenses. The anterior margin of the intercapsular bridge has a rounded hump on each side of a deep V-shaped depression on the median line. The posterior margin has a deep, narrow bay extending in for about two-thirds the length of the capsule.

The inner corner of the third segment of the palpi has about ten short spines, some of these being pectinate. Near the well-developed inner margin of the fourth segment four long spines may be found, and at the distal end there is a group of six shorter pectinate spines.

E. symmetrica is about 4 mm. in length, and at present is only reported from the coast of County Wexford in Ireland.

Eylais neglecta Thor. (Pl. 3, fig. 8).

1899. Sig Thor. *Arch. Naturv. Christian*, vol. xxi. (5) p. 12, pl. xvii. figs. 156–158.

The intercapsular bridge is of moderate breadth. The posterior margins form a deep bay which extends to near the middle of the eye capsules. The anterior margin is somewhat sinuate with a short depression on the median line. Behind this, there is a process serving for muscle attachment with a pair of hair pores on each side. There is a well-defined, though narrow, chitinous ring round each hair pore.

The distal area of the flexor surface of the third segment of the palp has eight to ten pectinate spines. On the flexor surface of the fourth segment there is an outer row of four to six long spines, and an inner row of three curved bristles, and six to eight pectinate spines.

The postero-lateral processes of the capitulum are fairly long; they are blunt and arched up from the end of the capitulum. The pharynx is without any prominent feature.

E. neglecta measures about 3 mm. in length. It has been recorded from Oban in Scotland, and from Ireland; it has also been noted from Norway, Sweden, Hungary and Switzerland, as well as from Asiatic Russia (Akmolinsk).

* **Eylais relicta** Halb. (Pl. 3, fig. 20).

1911. Halbert. *P. Irish Ac.*, vol. xxxi. (39 i), p. 6, pl. i. fig. 5.

The anterior margin of the intercapsular bridge possesses a broad process which is truncated at its extremity, and has a broad somewhat triangular subcutaneous portion. The posterior margin has a deep bay, which extends to nearly half the length of the capsules and varies in outline from an acute to a more or less rounded form. Each capsule is broad posteriorly, but is narrower anteriorly. The anterior lens is rather small with a short stalk.

The palpi are about 1·35 mm. length, and are more slender than those of *E. infundibulifera*. The distal inner margin of the second segment is without spines on its middle portion. Towards the distal end of the flexor surface there are three pectinate spines with two others on the margin. The extensor surface has seven or eight smooth bristles. The third segment is of about the same thickness throughout, and is thus without the usual development on the distal flexor surface. The proximal portion of the inner surface has eighteen or twenty spines, some of which are pectinate, and of these, eight are grouped distally. The fourth segment is also of nearly equal stoutness throughout, but its flexor surface is not so marked as in the case of *E. infundibulifera*. The proximal half of the inner surface has about thirty long spines, and at the distal end there are five or six pectinate ones. The fifth segment is slightly curved at its distal end. Its inner surface bears ten to twelve strong spines, and its outer surface seven or eight.

The capitulum is similar to that of *E. infundibulifera* and is about 0·58 mm. in length. The anterior and posterior processes are long and broad, the posterior pair being rounded at the extremities.

The legs range from about 2·90 mm. in the first pair to about 3·77 mm. in the fourth pair.

This species has been taken in Ireland at Glendalough Lake, Connemara, Castlebar Lough, Crincaum Lough on Cromaglaum Mountain, Killarney, and in England at Woking.

* **Eylais gigas** Piers. (Pl. 3, fig. 18).

1904. Piersig. *Annuaire Mus. St. Pétersb.* vol. ix. p. 55, fig. 6.

The intercapsular bridge bears some resemblance to that of *E. discreta*, but the anterior edge of the bridge is rather more wedge-shaped, its most anterior portion being thickened, with a V-shaped depression in the middle. The posterior edge lies well forward, leaving a deep bay between the capsules which lie obliquely to one another. They are wider at the posterior end than at the anterior, at the inner corner of which there is a long hair. In a single specimen, which was taken in Sweden, the capsules are so close to one another as almost to obliterate the intercapsular bridge. The English material ranges between the type and the Swedish form.

The third segment of the palp has thirteen to sixteen spines for the most part pectinate, from the rounded anterior end of the flexor surface downwards. The fourth segment has a row of five or six spines on its outer surface. On the ridge of the flexor surface there are two broad spines. The inner portion of the flexor surface has a double row of bristles for the most part pectinate. The second, third and fifth segments are of nearly equal length, while the fourth segment is nearly double the length of the second.

This is one of the big species, and is found from 4 mm. upwards in length. Besides being found in Russia and Sweden, it has been found in England in Hampshire, and at the Norfolk Broads.

* **Eylais infundibulifera** Koen. (Pl. 3, fig. 17).

1897. *Eylais infundibulifera* Koenike. *Abh. Nat. Ver. Bremen,* vol. xiv. p. 284, figs. 3–4; syn. *E. bifurca* Piers. (*vide* Halbert, *Ann. Nat. Hist.*, Ser. 7, vol. xii. p. 513).

This is a species in which the capacity for variation seems to be marked particularly in regard to the eye plate.

The eye capsules are nearly cylindical, the outer margin being weakly convex and the inner weakly concave. The distance between the capsules is about the same as the width of the capsules themselves. The anterior margin of the intercapsular bridge is continued into a broad ligulate process, serving for muscle attachment, while the posterior margin forms a deep bay. Measured from its anterior extremity to its posterior margin, the intercapsular bridge is of about the same length as the capsules.

The palpi measure up to 1·30 mm. in length, and are stoutly built, the third segment very much so. Its distal flexor surface projects slightly, and is covered with numerous short spines, some of these being indistinctly pectinate. The fourth segment has an inner row of numerous closely placed spines for the most part pectinate, and an outer row of nine short spines. The fifth segment is rather thick and blunt at the apex, and curves well to the flexor surface.

The antero-lateral processes of the capitulum are of moderate length, and are directed well backward, though they do not reach so far as the base of the posterior pair. The postero-lateral processes are strong and curve inwards. The pharynx is of moderate width, and extends beyond the postero-lateral processes. The slender air sacs are shorter than the pharynx. The mouth is circular and larger than that of *E. extendens*. The anterior portion of the maxillary plate is closely covered with large pores, and the antero-lateral corners are rounded.

The female measures up to 5 mm., and the male, distinguished by its funnel-shaped genital organ, up to 4 mm.

The species has been recorded from European and Asiatic Russia, from Hungary and Bohemia, and from Norway, Finland and Germany. Within the Britannic area it has been taken at a number of places in Ireland, and in England at Norfolk Broads, Epping Forest, Hampton Court and in S. Devon, and N. Wales.

[*E. projectus*. *Science Gossip*, N.S., vol. vii. p. 69. I think this should now be regarded as a form of *infundibulifera* Koen. —W.W.]

Eylais spinipons Thor. (Pl. 3, fig. 21).

1898. Sig Thor. *Arch. Naturv. Christian*, vol. xx. (3) p. 9.

E. spinipons in some specimens seems to come near to *E. discreta*, of which Piersig conjectured it might be a variety.

In the Irish material the extreme width over the eye capsules was about 0·38 mm., and the length up to 0·23 mm.; while of two English specimens referable to this species, one from Surrey, with a resemblance to *E. discreta*, measured correspondingly 0·27 mm. and 0·19 mm.; the other, from the Norfolk Broads, inclining to resemble *E. tenuipons* Thor, measured 0·28 mm. and 0·20 mm. The anterior margin of the intercapsular bridge is nearly straight, with a more or less small triangular process, which ends in two small points. The anterior ends of the capsules tend to be broader than the posterior ends, so that the space between the capsules is deep and wide.

The palpi are stout. The second segment may have up to eight spines on the distal margin, while the third segment may have from twelve to fourteen slender pectinate spines on its moderately well developed inner corner. The fourth segment is well furnished with spines along its inner margin.

The capitulum is broad and short, moderately emarginate on its anterior margin. The pharynx, which is longer than the air sacs, is narrow and of about the same width throughout.

E. spinipons was first found in Norway, and has been recorded from Ireland from near Gorey and Enniscorthy, and from near Dublin. The English localities are Surrey, Norfolk Broads and S. Devon.

* **Eylais meridionalis** Thon. (Pl. 3, fig. 22).

1899. Karl Thon. *Zool. Anz.*, vol. xxii. p. 445, fig. 5.

The eye capsules have their margins thick, indicating that they are of a somewhat stout structure. Their anterior end is nearly straight, posteriorly it is rounded, and the sides are moderately emarginate. The intercapsular bridge is narrow, and its length is about half that of the capsules. The anterior portion of the bridge forms a well-marked cone-shaped process. There are a few irregularly shaped protuberances, which serve for muscle attachment.

The palpi are about 1·14 mm. in length, and thinner than the first pair of legs. The second segment is stouter than the others, and has the distal end well developed and fringed with about twelve bristles, of which part are pectinate. The third segment is more slender, having a low, rounded protuberance on its flexor surface with a group of long, slender bristles of which about five are pectinate. The fourth segment is more slender than the third, and more than twice as long; except for its slightly thicker proximal end it is of nearly equal thickness throughout. There is an inner row of ten long, smooth bristles terminating distally in a group of four similar bristles and two or three short, stout pectinate ones. There is further an outer row of three pectinate bristles, and eight or nine short, smooth ones arranged irregularly. The fifth segment is relatively long, with a row of short spines on its flexor surface.

The capitulum is small, compared with the size of the epimera. Its breadth at the anterior end, where it is marked by a broad, deep median cleft, is about equal to its entire length. The antero-lateral corners are somewhat pointed. The lateral margins curve inwards towards the posterior, so that the margin there is about half that of the anterior end. The anterior processes are slender, spreading out to near the base of the short and stout posterior processes, which are not thickened at their extremity. The maxillary plate is for the most part coarsely perforate. The pharynx is relatively narrow, and is slightly contracted in front of the narrow pharyngeal ridge. The metapharynx is rather long, and is narrower than the pharynx itself. The air sacs are short and thin.

The margins of the epimera are strong and broad. All of the pairs are of approximately equal width, and long in proportion, though the third pair scarcely extends beyond the others. The subcutaneous processes at the inner ends are small and coarsely granulate.

The legs range from about 2·67 mm. in the first pair to about 3·57 mm. in the fourth pair. Relatively, the swimming hairs are short.

Hitherto its distribution has been confined to Bohemia. An Eylais taken in 1901 in N. Wales appears to be referable to this species, which in some respects comes close to *E. infundibulifera* and to the variation of it which Piersig called *bifurca*.

Eylais wilsoni Soar.

1917. Soar. *Journ. Q.M.C.*, Ser. 2, vol. xiii. p. 281, pl. xxi.

The striking feature of this species is the absence of the intercapsular bridge. As this species has been so recently described, reference may be made to vol. xiii. of this *Journal.*

† **Eylais bisinuosa** Piers. (Pl. 3, fig. 23).

1899. Piersig. *Zool. Anz.*, vol. xxii. p. 62, fig. 1.
1901. *E. dividuus* Soar. *Sc. Goss.*, N.S., vol. viii. p. 68.

The name *bisinuosa* has not up to this time appeared among those recorded as found in the Britannic area, but material taken at the Norfolk Broads in 1904 appears to be referable to this species.

The eye capsules of *bisinuosa* are short and broad. On the inner side they are much rounded, but on the outer they exhibit a very weak concave surface. The bridge between the capsules occupies the anterior half of the space, the posterior margin being more or less straight, while the anterior margin is recessed to form a deep bay. The process for muscle attachment is round and large enough to slightly overlap anteriorly.

The distal end of the flexor surface of the third segment of the palpi is prominently developed, and is adorned with a group of six to ten short and broad spines. The outer surface of the fourth segment has four strong, smooth bristles, while the inner surface has also four, one being pectinate. Distally there are five or six flat pectinate spines.

The capitulum is distinctly long and slender, with the anterior end very much broader than the posterior. At the anterior end there is a sharp, broad incision in the middle, where the plate is somewhat elevated above the rest of the surface. The lateral edges are straight and converge posteriorly, so that the elliptical pharynx overlaps them. The anterior processes are not broadened out distally, while the posterior pair are moderately so, and are curved. Between the extremities of these the slender pharyngeal ridge is situated. The air sacs are long and fairly stout, and are curved similarly to the posterior processes.

The subcutaneous processes at the inner ends of the first two pairs of epimera are unusually large. Those at the end of the third and fourth pairs are long.

[I have referred *E. dividuus* Soar, which was taken at E. London Water Works in 1900, to *bisinuosa*. The accumulation of evidence of the capacity for variation impels one to a restriction of species wherever possible.—W. W.]

Description of Plate 3.

Eye Plates of Eylais.

1. *E. soari* Piers.
2. *E. soari* var. *instabilis* Halb.
3. *E. mülleri* Koen.
4. *E. rimosa* Piers.
5. *E. unisinuata* Cron.
6. *E. koenikei* Halb.
7. *E. symmetrica* Halb.
8. *E. neglecta* Thor.
9. *E. hamata* Koen.
10. *E. extendens* Müll.
11. *E. undulosa* Koen.
12. *E. celtica* Halb.
13. *E. discreta* Koen.
14. *E. discreta* var. *stagnalis* Halb.
15. *E. similis* Thon.
16. *E. triarcuata* Piers.
17. *E. infundibulifera* Koen.
18. *E. gigas* Piers.
19. *E. bicornuta* Halb.
20. *E. relicta* Halb.
21. *E. spinipons* Thor.
22. *E. meridionalis* Thon.
23. *E. bisinuosa* Piers.

All figures about same magnification.

A LOG AND SOME MYCETOZOA.

By A. E. Hilton.

(*Read March 9th*, 1920.)

In a shady corner of my garden at North Finchley is a log which looks hoary with age. The bark is deeply furrowed ; some of it is loose, and much is missing. The wood is rotting, and so spongy in places that birds peck pieces from it, probably hunting for larvae. It is the home of myriad insects, and has been the abode of several kinds of Mycetozoa.

Seven years ago it was the living trunk of a lime tree ; not, I think, the small-leaved lime tree (*Tilia Europaea*) but *T. platyphylla*, the leaves of which are broader and larger. Its age, when cut down, I cannot tell. The diameter of the log is about fifteen inches, but the rings at the sawn ends are too obscured to be counted. It was soon attacked by fungus, chiefly Polyporus, and penetration of the wood by mycelial threads hastened decay, and helped to prepare a habitat for Mycetozoa.

I first found Mycetozoa on the log in August 1915, after a month or more of heavy and frequent showers, and warm temperature (about 20° C.). A crowded patch of minute sporangia of *Perichaena corticalis* then appeared, covering about one square inch. When discovered these were brown, but they afterwards became grey with calcareous deposits, and in a day or two were disfigured with fungus hyphae.

My next record shows that three years later, in the middle of August 1918, after a fortnight of fine and warm weather (again about 20° C.) had followed a period of wet and unsettled conditions, the appearance on the log of patches of light yellow enabled me to watch the formation of aethalia of *Fuligo septica*. When first seen, at 4.15 p.m., the emerging plasm covered about twelve square inches. It then seemed to be a thin layer gathering up into small papillary sporangia, very confluent and indeterminate.

By next morning the plasm, which had continued issuing from the wood, was in much greater volume, and in two cushion-like masses; a larger mass, 4·5 × 3·5 inches, on the highest part of the log, and a smaller mass, about one inch in diameter, lower down, and about eleven inches distant, but probably part of the same plasmodium. The average depth of the larger cushion was about half an inch. The colour was still light yellow, but by noon this had changed to a yellowish white with light-brown patches and smaller blotches of a reddish tint where the plasm had been disturbed by raindrops or other interferences. When matured and dry the prevailing tone was whitish brown and cracks in the surface revealed dark masses of spores within. The aethalia were left in position, but gradually disappeared; and, so far, there has been no repetition.

Two months later, in October 1918, a patch of Trichia, probably *T. scabra*, appeared; but I did not detect it in time to follow the development, neither could I identify it with certainty, the specific characters being indistinct. The small sporangia, sessile and crowded, were of a slightly brownish-orange colour.

In the spring of last year, a quantity of spores of *Reticularia lycoperdon* were sown on the log, but no results are yet visible. Other spores from the same source have since germinated freely in water; so that this negative experience is difficult to account for, especially as Reticularia and Fuligo are very similar in their general habit.

There are so few Mycetozoa in the neighbourhood that the subsequent occurrence of seven species on this one log is remarkable; but there is no mystery about it. For some time past I have scattered upon it spores for which I had no other use; and as I have sown, so, in a measure, have I reaped. All the Mycetozoa mentioned in the remaining paragraphs were species of which I had sown spores, so that no further explanation is necessary.

Towards the end of May last, this series of notable incidents began with the appearance on the log of *Lycogala epidendrum*, followed a month later by two more groups of the same kind, about three feet apart. The aethalia of this species are spherical, from 1/8 to 3/8 of an inch in diameter. When first seen on the log, they were tiny globules of plasm of a light orange colour, which in a few hours became twice the size, and of a pinkish tinge. In less than twenty-four hours from the first observation they were fully formed, and of a light salmon-pink colour, vivid and arresting. Next day this had deepened, and by the day following had changed to a light buff. Two days later they had finally dried off to a buff colour with a greenish brown tint. On each occasion the temperature was about 20° C.; the first group appeared on a showery day, after a spell of dry weather which had become rather close; and the other two groups were formed a few days after there had been much rain and occasional thunder. The plasmodia of Mycetozoa appear to be very sensitive to electrical conditions, as I have several times found that in wet and close or thundery weather they are apt to pass into the sporangial stage.

Now comes the remarkable part of my story. The first Lycogala were quickly followed by other kinds of Mycetozoa; and my record shows that, on an average, from the last week in May till the first week in October, plasm issued from the log on, approximately, two days out of every three. In July there was but one day on which no new emergence could be found; and the longest break was towards the end of September, when there was an interval of a week without any fresh developments; but the weather was then cooler, and after a last emergence of plasm on October 4th, a rapid fall in temperature brought the series to an end.

The Mycetozoa included in these sequences were chiefly Stemonitaceae · *Stemonitis fusca, S. ferruginea, Lamproderma columbinum* and one small group of *Comatricha nigra.* The remainder consisted of the Lycogala already described, two small clusters of the beautiful *Arcyria denudata* and four little patches of *Physarum nutans.*

A description of the formation of sporangia of Stemonitis was given in a previous paper * and need not be repeated here; but one incident occurred which ought to be mentioned. On July 20th three patches of white plasm, one to two inches in diameter, issued from the log through crevices in the bark and proceeded to develop in the normal manner; but before the process was at all complete, they were drenched by a heavy shower of rain. The result of this disturbance and dilution was that instead of forming tall and slender cylindrical sporangia elevated on stalks,

* *Journ. Quekett Microscopical Club,* April 1916.

the plasm simply settled down into rounded masses of spores and capillitium, without surface nets or columellae. In other words, they answered to Lister's description of *Stemonitis fusca* var. *confluens*; but the confluent condition was clearly accidental. The spores were unaffected, and readily germinated in water.

During the four months under review, the most frequent appearances were those of *Lamproderma columbinum*. They are first visible as small, watery-white, semi-translucent globules, more or less clustered into little groups. The plasm then secretes stalks and columellae, and forms vertical cylindrical sporangia, 1/8 of an inch high, which after turning pinkish, reddish brown, and then black, dry off to a bronze-like or brassy lustre, the process occupying two or three days.

Attempts which I have made to trace the plasmodia of this species within the interstices of the wood have failed. The interior of fragments taken from the log while sporangia were rising presented only a wet appearance, indistinguishable from ordinary moisture; and when pressed out on to a glass slip, and placed under the microscope, the fluid merely exhibited a miscellaneous gathering of fungoid and bacterial bodies, together with other elements which were possibly ingredients of plasmodia. It is probable that while within the wood the plasm is watery-clear, and the plasmodium so ill-defined that it only becomes distinguishable on emerging to the surface.

One patch of Lamproderma which appeared in July was about eight inches long; and another patch, two months later, covered twenty square inches; but for the most part, the groups were small and very scattered, suggesting independent developments of small and separate plasmodia rather than those of larger plasmodia, maturing in various parts at different times.

The four little groups of *Physarum nutans* which appeared on the log, one at the end of July and the others a month later, were first discernible as minute masses of plasm of a dull yellow colour speckled with lime granules. Under the microscope, with 1/2 inch objective, a wrinkled and iridescent membrane could be seen between the lime clusters; but as development proceeded, the lime at the surface increased until the sporangia were completely covered with a frail calcareous crust.

Coming now to generalities, my daily records show that during these four months of activity, from the end of May to the beginning of October last, the temperature fluctuated greatly; but they point to the conclusion that for the developments which took place a mean temperature of 19° or 20° C. was most favourable.

To maintain the activities of plasm, however, much moisture is necessary, and occasionally, when the atmosphere was dry and hot, the log was watered to replace loss by evaporation. It was largely the combination of warmth and moisture which kept matters going.

As regards the behaviour of plasmodia within the wood, we can only judge by inference. When in that position they obviously cannot have the same freedom of movement as those which openly spread over dead leaves and tree stumps as networks of amoeboid plasm. Their liberty is, indeed, much restricted, and the controlling factors are not wholly apparent; but at least some of them are clear. In rotting timber, decay mainly follows the direction of the grain; moisture flows by capillary attraction or gravitation along the channels of decay; and spores, swarm-spores and plasmodia are liable to be carried along by the currents. Thus, the more extended patches of Lamproderma always developed on the log in a longitudinal direction, parallel with the grain. Again, at one extremity the wood has partially split; the rain finds its way down the fissure until it reaches an outlet on the sawn face at the end of the log; and the most abundant developments of Stemonitis and Lamproderma were round about this outlet. Other cases suggested, not gravitational, but capillary effects. For example, on the highest and driest part of the log is a spot where stumps of shoots remain fixed in the wood; and plasmodia of Lycogala and Lamproderma have come to the surface by way of the crevices surrounding these insets. It is possible that increases in the volume of plasm, by growth or absorption of moisture, may have found an outlet in the upward direction as the line of least resistance; but heat or dryness of the air would undoubtedly set up capillary currents of moisture from the interior to the surface of the log, and these might easily assist in bringing plasmodia to the light of day. Such conclusions by no means preclude other and more obscure reasons for emergence, probably inherent in plasmodia ready to form sporangia.

Not many specimens were removed from the log; they were mostly left to take their natural course, and soon disappeared. Birds and insects, wind, rain and falling leaves, quickly destroyed the frail sporangia, and a few weeks after the final developments it was difficult to discover any traces of them.

That all traces of them are so soon lost adds to the mystery of the Mycetozoa. They are strange creatures; but their strangeness is rather misunderstood. The frequent inquiry as to whether they are animals or plants is beside the mark; because there is no clear division between the two groups, and you cannot, without reservation, place Mycetozoa either in one or the other. All that can fairly be said is that, in the round of their life-cycle, animal nature appears to preponderate. Beyond that point it is purely a matter of defining the terms; and as there is no clear principle on which this can be done, the question is meaningless.

The real mystery is their history. They are organisms of a primitive kind, and their wide distribution over the globe is presumptive evidence of early origin; but no record of their remoter past is ever likely to come to light. Whether they have ever attained to higher developments, or have degenerated, we do not know; but making all allowance for possibility of survival owing to the minuteness, multiplicity and resistance of the spores, it seems incredible that such frail organisms can have come down to us in an unbroken line from the earlier days of the appearance of life upon this planet. Yet we have no assurance that conditions for a fresh production of living things have prevailed at any later period; so there the matter rests.

The attraction of Mycetozoa is not the mystery they conceal, but the life they reveal. Of their vital transformations, descriptions give no adequate idea. You need to see the translucent plasm nakedly emerging from haunts of rottenness: to watch the sensitive forms taking shape and colour, while changing tints betray, as if consciously, the inward processes: until the living elements, thus briefly unveiled, retreat into the seclusion of the spores. When you have seen this with discerning eyes, you understand the fascination of the Mycetozoa.

THE DESMID FLORA OF A TRIASSIC DISTRICT.

By G. T. Harris.

Communicated by the Hon. Editor.

(*Read June 8th,* 1920.)

The district dealt with in this paper is situated entirely in East Devon, between the estuary of the Exe on the western side and the estuary of the Axe on the eastern side of the district. It is in Watson's phyto-geographical district V.C.3, and in the Honiton Division (5) of the county of Devon, as divided by Mr. W. P. Hiern for botanical references (**2**), and which has been adopted by the Botanical Sub-Committee of The Devonshire Association. Beyond a few records by E. Parfitt (**1**) of the commoner species from Woodbury Common no published records appear to have been made. W. and G. S. West's records from Devonshire (**3**) appear to be altogether from the district west of the Exe estuary, Dawlish, Torquay and parts of Dartmoor (principally the eastern fringe); and Joshua's (**4**) were probably more or less from the same district as those of Bennett (**5**) : the Haytor and Bovey Tracey. The portion actually collected over reached to the Exe River in the west, between Topsham and Countess Weir, nearly to the Axe at Seaton in the east, and to Honiton and Broadhembury in the north; an area roughly of about 160 square miles. But the principal collecting was done within much narrower limits, being a small portion bounded by Woodbury Common in the west, Weston Mouth in the east, and Broad Down near Farway in the north, this restricted area corresponding with the district collected over when engaged on the Moss Flora of the district (**6**). It is from this smaller portion (about five square miles) that the whole of the records in the present paper have been compiled. The area is a flat tableland sloping gradually from an elevation of about 885 feet in the northern portion to 400 and 500 feet in the southern, and is deeply excavated into valleys and combes by the rivers Axe, Sid and Otter with their numerous tributaries. The flat hill-tops are principally beds of chert and flint embedded in a stiff yellow marl, below this appear Cretaceous sands and sandstones, these beds resting on the Keuper marls between Sidmouth and Seaton. Westwards of the Otter Valley the district is mainly occupied by the Budleigh Salterton Pebble bed which forms Woodbury Common, and which also rests on the Keuper Marl. The numerous springs that break out on the hill-sides at the junction of the Keuper Marl, with the overlying beds give rise to small bogs of varying dimensions, and it is in these bogs that the principal collecting has been done.

While the present paper may be taken as a further contribution to the Desmid Flora of Devon, the main object in view when projecting the investigation was to compare the result with that derived from an examination of the Desmid Flora of Dartmoor (**7**) in order that comparison might elucidate in some measure the influence of geological beds on the species density of the Desmid Flora ; that is to say, to ascertain if the Desmid flora of comparatively recent geological beds would stand comparison with such a proved rich Desmid area as Dartmoor, a Palaeozoic moorland district, with ancient and extensive bogs, mountainous altitudes (up to 2,039 feet) and excessive rainfall (up to 80 inches). The late Professor G. S. West insisted that only on the older Palaeozoic beds, and on the Pre-Cambrian beds, could rich Desmid areas be found. He distinctly states that "The rich Desmid areas correspond geographically with the Pre-Cambrian and older Palæozoic out-crops" (**9**) ; that, "In the British Isles, the really rich Desmid floras are only to be found in those areas which combine the most suitable habitats with a drainage water derived from geological formations older than the Carboniferous" (**9**). What Professor West understood by a rich Desmid area may be gathered from his own writings : "We do not apply the term 'rich' to a mere abundance of Desmids, or even to the occurrence of a great quantity of thirty or forty species, but only to those areas in which 150–200 (or even 300) species can be found in more or less abundance" (**9**). Dartmoor by no means fulfils the conditions formulated by Professor West for an ideal Desmid area, nor does it bear comparison geologically with the Welsh Lake District, or the Outer Hebrides with their ancient beds of Lewisian granite, yet the Desmid flora of Dartmoor (if one may judge from the published lists of Professor West for Scotland on the one hand and of myself for Dartmoor on the other) is quite equal to the far older geological districts indicated by Professor West. The census list for Dartmoor now stands at 290 species, 92 varieties, and about 30 forms, which figures should be compared with 236 species and 68 varieties given as the total Desmid flora of the British phyto-plankton (**9**). It is obvious, therefore, that Dartmoor with its Post-Carboniferous granite is equally rich with the Desmid areas on the Lewisian granite. A consideration of this result suggested the systematic examination of the Desmid flora on beds of a still more recent geological period in order that some idea might be obtained of how far that flora was influenced by the character of the beds upon which its habitats occurred.

The methods of collecting were the same as those adopted for the Dartmoor district (**10**) ; the total time expended on the field work, and the number of gatherings made, was roughly also the same as for Dartmoor. As a rough guide to the richness of the gatherings a "spread" under an inch cover glass was prepared and the total of species, varieties and forms noted. From the Dartmoor bogs a gathering that gave a total of sixty by such a method was regarded as of maximum richness, and similar totals were obtained from the better bogs in the present district. With regard to the individual richness of the bogs in the two districts some difficulty was experienced in arriving at comparable results owing to the widely different character of their formations. The bogs collected from on Dartmoor are clearly marked areas due to depressions in the granite floor, whereas the bogs in the present district being on an inclined plane have no definitely outlined boundaries, but often succeed one another over considerable distances. Where it was found possible to work out a fairly isolated bog the numerical results were surprisingly close to those of the Dartmoor bogs—that is to say, the less important yielded an average of from 80 to 90 records, while up to 150 might be obtained from more extensive localities. The material was collected during the months May to October in the years 1917–1918, no gathering worthy of mention being made in the year 1919. The average rainfall for the district in the years 1916–17–18 was 35·27 inches and the mean temperature, 49·5 degrees; the average rainfall being about 50 per cent. less than Dartmoor.

The comparative table here given of the Desmid floras of the two districts (Dartmoor and East Devon), one a Palaeozoic semi-mountainous area of extensive peat deposits, excessive rainfall and deep bogs, the other a Triassic lowland area, with no peat deposits, moderate rainfall and bogs unimportant both in depth and extent, would indicate that the factors influencing the richness or poverty of Desmid floras must be sought for elsewhere than in the geological beds upon which the habitats stand, and a recent investigation of the Desmid flora of a district on Eocene beds confirms this statement. It is also noteworthy that the species density of the two districts is practically the same, for although exact scientific methods could not be applied to the field work, an approximation was made in the extent of ground examined and amount of time devoted both to collecting and examining the material, so that the comparison is a fairly accurate one.

Comparative Table of the Desmid Floras of a Palaeozoic (Carboniferous) and Triassic District.

Genus.	East Devon.			Dartmoor.			Percentage of British species.	
	Spp.	Vars.	Forms.	Spp.	Vars.	Forms.	East Devon.	Dart-moor.
Gonatyzogon	3	2	—	4	1	—	60	80
Spirotaenia	7	—	—	6	—	—	50	42
Mesotaenium	9	2	—	3	—	—	90	30
Cylindrocystis	4	1	—	4	1	—	66	66
Netrium	4	3	—	3	3	—	100	75
Penium	18	3	5	18	3	3	66	66
Roya	2	—	—	2	1	—	66	66
Closterium	39	14	—	32	12	—	60	53
Pleurotaenium	3	3	—	1	—	—	33	11
Docidium	1	—	—	—	—	—	33	—
Tetmemorus	4	2	—	4	2	—	100	100
Euastrum	22	6	4	31	5	4	50	70
Micrasterias	5	6	1	5	5	1	31	31
Cosmarium	101	50	15	83	38	13	40	33
Xanthidium	6	1	—	7	1	—	42	50
Arthrodesmus	7	4	3	7	6	5	63	63
Staurastrum	44	9	2	61	14	3	26	36
Cosmocladium	—	—	—	1	—	—	—	—
Sphaerozosma	2	—	—	5	—	—	40	100
Hyalotheca	2	1	—	2	—	—	50	50
Desmidium	2	—	—	2	—	—	33	33
Gymnozyga	1	—	—	1	—	—	100	100
Spondylosium	1	—	—	—	—	—	14	—
	287	107	30	282	92	29	—	—

The Census List at the end of this paper adds 122 species and varieties to the Desmid flora of Devonshire, bringing it up to a total of about 500 species and varieties, collected principally from the districts of East Devon and Dartmoor. Zygospores when observed have been specially noted in the list in connection with their respective species, principally because they occurred in the vernal gatherings, and the assumption hitherto has been that zygospores were more or less an autumnal production. They appear to be freely produced by some species as early as March and April, in fact it was not uncommon to find them present in gatherings made in the winter months, and in such a condition as would indicate that they were the result of recent conjugation. With the view of obtaining some knowledge of the continuance of the vegetative stage of Desmids through the winter months gatherings were made from the bogs on Beacon Hill and Harcombe and the material when worked out compared with gatherings made in late spring and early summer of the previous two years. The winter gathering on Beacon Hill yielded 50 per cent of the summer gathering in species and varieties, and the bog on Harcombe also 50 per cent. of the summer total. In considering these figures, however, it should be remembered that whereas the summer lists were made from several gatherings of considerable bulk, the winter lists are from one gathering only and that not a large one. It would appear that most species in a southern county like Devonshire pass the winter in the vegetative state.

Two Desmids are conspicuously absent from East Devon (*i.e.* from the present collecting stations), *Euastrum cuneatum* Jenn. and *Euastrum insigne* Hass. Their absence is very unaccountable, as they are widespread on Dartmoor and also in the New Forest, indeed *Euastrum cuneatum* occurs so abundantly in some of the New Forest bogs that one is inclined to regard it as a lowland species.

Where the specific dimensions have been found to differ materially from those given in West's *Monograph of the British Desmidiaceae* (**11**), a note has been made of the fact by giving the measurements in brackets, these measurements extending the ranges of specific limitations given in the monograph either in a maximum or minimum direction.

The nomenclature throughout is that adopted by the Wests in their *Monograph on the British Desmidiaceae* (**11**) except for that portion of the genus Staurastrum which remains uncompleted in the monograph. For this remaining portion I have been compelled to use that of Cooke in *British Desmids* (**12**) and Wolle, *Desmids of the United States* (**13**).

The whole of the material which forms the basis of this paper was collected and worked out by myself, consequently I am responsible for any errors of determination, etc.

The capital letters in the first column of the Census List indicating the relative frequency or infrequency of the species, etc., apply to the district as a whole, and not to the individual stations from which it was collected. A species may be fairly common in the particular station from which it was collected, although rarely occurring in the entire district.

In conclusion, I would offer my sincere thanks to the Quekett Microscopical Club for affording me the opportunity of publication in their *Journal*; the more so as I am fully aware of the difficulties under which the scientific societies are labouring to carry on the publication of their proceedings.

Physical Descriptions of the Bogs from which Collections were made.

Woodbury Common.—This is by far the most important collecting ground in the whole district. It is an elevated ridge, running north from the coast near Budleigh Salterton to near Larkbeare, a distance of some eleven miles, with an average breadth of from one and a half to two miles, and a height varying from about 400 to nearly 600 feet above sea level. This ridge is composed almost continuously of the Budleigh Pebble beds resting on underlying New Red Marls, and is an undulating district of common land, covered with furze, heather and bracken. In the southern portion of the common, on the eastern side, are deep gullies whose bottoms contain small rivulets bounded on either side by boggy margins. These bogs are quite different in formation from those in the northern part. There the bogs are due to springs breaking out at the junction of the underlying New Red Marls with the Pebble beds, and consist of a shallow depth of water flowing gently down an inclined surface, frequently paved with pebbles redeposited from the beds above. The depth of water in such bogs is seldom more than an inch or two, except where small depressions occur. Such bogs often cover extensive patches on the sloping sides of the common, creeping down to a small stream that flows through the bottom and discharges into the River Otter. These shallow bogs are particularly well aerated and have a rich Algal flora irrespective of the Desmidiaceae. One of the principal features is the prolific growth of *Stigonema ocellatum* Dillw., which occurs in extensive mats spreading over the surface of the bog. Associated with this is a rich growth of Protococcoidae and Conjugatae, and the exuded mucilage of the various species accumulates to such an extent that large masses of it may be lifted out. In a long dry spell of weather in the early summer of 1916 one of these bogs presented an extraordinary sight, being largely a huge collection of mucilage. In addition to the Algal flora these bogs possess a hydrophytic Moss flora of considerable richness and variety, and a curious feature of this Bryophytic flora is an endeavour to adapt itself to the shallow-water conditions. *Hypnum scorpioides* L. is particularly noticeable for this adaptation, though *Sphagnum subsecundum* var. *contortum* Schp., and *Sphagnum subsecundum* var. *turgidum* C.M., also exhibit it. The growth takes place horizontally along the floor of the bog, so that the plant is always covered by the shallow depth of water; moreover they, in common with the dicotylous macrophytes growing there, are abundantly covered with the mucus excreted by the algal growth. These bogs are densely populated with Desmidiaceae, as the following summary from my field-book will show: "Aylesbeare Common, north bog, April 29th, 1917. Closterium, 22; Euastrum, 14; Micrasterias, 3; Cosmarium, 43; Staurastrum, 25; Penium, 12; Various genera, 21."

The bogs in the southern portion of Woodbury Common are different, inclining rather to High Moor formation, and the Desmid flora has a somewhat different facies by the inclusion of species more often found in bogs at a greater altitude. *Xanthidium antilopaeum*, *X. Smithii*, *X. variable*, *Arthrodesmus convergens*, *A. octocornis*, *Staurastrum brachiatum*, *Desmidium Swartzii*, *D. cylindricum*, *Arthrodesmus trispinatus*, *A. subulatus* var. *subaequalis*, and many others occur in the southern bogs that do not appear in the bogs in the northern portion. The total number of species, varieties and forms collected from Woodbury Common is 367.

Harcombe Bog.—This small bog is caused by springs that break out at the junction of the Keuper Marls with the overlying Greensand and Cretaceous beds. It is of no great extent and quite inconsiderable depth, the whole being little more than a boggy hill-side. It is situated on the eastern slope of one of the long parallel ridges that traverse East Devon from north to south, and is nearly on the 500-feet contour line. Its interest arises from the fact that its drainage water is derived from the super-incumbent Cretaceous beds, so that the bog may be regarded almost as much a Cretaceous as a Triassic habitat; probably an important point, however, being that the water is filtered by passing through the Greensand beds before it reaches the bog at the junction with the Marls. Notwithstanding its meagre area and semi-calciphilous conditions, the Desmid flora is quite equal in number of species and varieties to a second-rate Dartmoor bog, its census list being about 113 species and varieties. One notable feature in connection with it is the total absence of any member of the genus Mesotaenium, in this respect differing markedly from the Woodbury Common bogs, which are particularly rich in them. A few individuals of the common *Arthrodesmus Incus* represent the genus Arthrodesmus. There is also a remarkable absence of *Micrasterias denticulata.* Pure gatherings were often made of *Closterium Lunula* and *Euastrum crassum,* and the alga *Eremosphaera viridis* was often present in prodigious quantities.

Beacon Hill.—This bog is similar in physical conditions to the one at Harcombe. Like that it exists where the springs break out at the junction of the Greensand beds with the Keuper Marls. It is also at about the same altitude. It is, however, of rather greater extent, and in places probably a foot in depth, owing to a considerable growth of Sphagnum, principally *S. acutifolium* and *S. cymbifolium,* with several varieties. At one spot a small fount of water forces itself to the surface and flows down the hill-side, the swampy area around the spring being richly covered with various dicotylous hydrophytes. No Desmids occur around the spring, these being replaced by a luxuriant growth of Diatoms. It is probable that at this spot the water is richer in silica derived from the Greensand beds than in other parts of the bog, and that the Desmid flora has been expelled by the more vigorous competition of the Diatom growth. This bog, with a census total of 138, must be considered rich, having regard to its small dimensions. Like the Harcombe bog it produces no member of the genus Mesotaenium, nor does it appear to contain any member of the genus Arthrodesmus, and only *Xanthidium armatum* in the genus Xanthidium.

Ring i' th' Mire Bog.—Considerable interest attaches to this station on account of its position and the beds upon which it is situated. It is at the highest altitude in the district, 812 feet, on that portion of the East Devon plateau known as Broad Down. This is an extent of stiff Cretaceous clay intermixed with flint and chert. Here and there are shallow depressions of no extent which become filled during the winter rains and gradually dry up as summer progresses, unless a wet season keeps refilling them. The small bog known as "Ring i' th' Mire" is the only approach to a permanent bog on the plateau, and it almost dries out in a dry summer. Although local legends have no value as scientific evidence, there may always be a residuum of truth in them, and a local legend connected with this spot indicates a much more extensive "mire" in former times, so that the Desmid flora at present existing may be regarded as the remnant of a much more extensive one. The bog is so situated that no contributions to its Desmid flora could possibly be made from stations of superior altitude. It is quite isolated, and must have been so since Gittisham Hill, upon which it stands, was severed from St. Cyres Hill across the valley of the Otter. The Desmid flora of this bog may therefore be regarded as the survival of an ancient Desmid flora derived from the Blackdown Hills when the land surface between was of more or less uniform level. It will be seen that, situated as it is upon Cretaceous beds, it has strictly speaking no place in this paper, and is included merely for comparison with other stations in the district, and because of its unique position. The total census number, 118, is sufficiently striking, having regard to its extremely meagre proportions and to the fact that during the greater portion of the vegetative season it is almost completely dry.

Pools and Ditches.—Small pools such as occur plentifully in more level counties are very infrequent in East Devon on account of the comparatively small amount of level surface. Such as do occur are principally made by farmers for watering cattle on the farms. They are quite small, often dry, and when full so frequently disturbed by cattle that no vegetation has a chance of developing. Quite often, however, on the commons, small pools will be formed in depressions of the land, but these have been ignored when filling in the records for this column, as their Desmid flora has nearly always been derived from bogs situated at a higher level, from which the water has been derived. Good roadside ditches also are conspicuously absent from the district, as the drainage of the land surface is too effective for any standing or slow-running water. Hence it is not surprising that this column of the Census List makes but a poor contribution. One notable feature, however, is connected with an examination of such pools as do exist in the district, this is the occurrence of what may be termed *Closteria pools.* These pools are densely populated with both species and individuals of the genus Closterium. On Dartmoor I met with the same feature in one pool, which was almost exclusively populated by various species of Closterium. In the present district a very notable example occurred, which was an extremely small pond without any macrophytic vegetation, but prolific in Closteria, fifteen species being collected from it, all in profusion, but *Closterium angustatum* being the dominant species. On a "spread" one-inch cover-glass nearly 200 individuals of this species were counted: very few Desmids of other genera were present, but *Oscillatoria princeps* Vauch. was abundant in the pond. In East Devon, *Closterium Malinvernianum* seems restricted to ponds, and is rarely found even in them. *Cosmarium Corbula* has only been found in one small hill pond, but there it occurred in abundance.

Although it has no connection with the present paper, it may be of interest to mention a Closterium habitat that appears somewhat unusual. The species concerned is *Closterium moniliferum* Ehrenb., a species by no means common in Devonshire, and one that is more or less confined to small pools and ditches. In the present instance, however, it occurred in the swift water of the Teign River at Fingle Bridge. Some alder trees growing on the banks of the river had had their roots exposed by the bank having been washed away, and the fine rootlets were floating in long streamers in the swift water of the river. These fine rootlets were crowded with innumerable individuals of the above species attached by one apex of the cell. The velocity of the river at this spot, added to the turbulent tossing to and fro of the rootlets in the water, enabled one to form an estimate of the adhesive properties of the mucilage excreted by the Desmid.

Special Notes on Some Species.

Spirotaenia fusiformis, W. and G. S. West. This rare species, only recorded in West's *British Desmids* from Cowgill Moss, Yorks., occurred in the southern portion of Woodbury Common in a small well-aerated bog.

Mesotaenium De Greyi var. *breve* W. and G. S. West. Hitherto only recorded from the Torc Mountains.

Mesotaenium purpureum W. and G. S. West. Only recorded from Cote Moor, Yorks. The Woodbury Common specimens are smaller than West's measurements.

Cylindrocystis Brebissonii Menegh. This common and widespread Desmid occurred in prodigious quantities in the intake beds of the Exmouth Reservoir on Woodbury Common. Large masses of mucilage floating in the water consisted of practically pure gatherings of this Desmid.

Netrium interruptum W. and G. S. West. So many specimens of this species were collected on Woodbury Common with continuous, undivided chloroplasts that it may be doubted if the interrupted chloroplast is of any specific value.

Closterium praelongum Bréb. Apparently a very rare Desmid in Devonshire. The Exeter Canal at Countess Weir is the only station from which I have collected it.

Closterium Malinverianum De Not. A rare Desmid in Devonshire, and almost entirely confined to sluggish streams, such as the canal at Countess Weir.

Docidium baculum Bréb. The late Professor G. S. West, in a letter to me, remarked on the absence of this Desmid and *Pleurotaenium truncatum* (Bréb.) Nag. from the Dartmoor census list. (*Journal Q.M.C.*, vol. xiii, April 1917). In the East Devon district they occur, but with no great frequency. In the New Forest during a recent collecting trip, I was at once struck with the great abundance of various species of Pleurotaenium and Docidium, clearly indicating a preference for a lowland habitat.

Micrasterias Americana and vars. This species was only once collected. It occurred with the two varieties given in the Census List in an almost dried-up depression on Woodbury Common, containing scarcely any water beyond the small amount present in the sphagnum growing there.

Cosmarium oblongum Benn. After careful examination of several specimens gathered on Woodbury Common, I have come to the conclusion that they are really so near Bennett's description of *C. oblongum* that they should be so named, as the species is admitted to the British Desmidiaceae. The measurements of the Woodbury Common specimens are too small for *C. Hibernicum* West, and not small enough for *C. viride* (Corda) Joshua. It would undoubtedly be better to sink Bennett's species to a variety of *C. viride* to which it obviously belongs.

C. Corbula Bréb. This is a very rare Desmid in Devonshire, and was met with in only one locality, where, however, it occurred in some profusion and with plenty of zygospores.

Desmidium Swartzii Ag. This Desmid is much more plentiful in East Devon than it is on Dartmoor, at the same time it is by no means common. It would appear to be a species that finds its most favourable habitat in lowland, still ponds, as I have collected it in great quantities in the New Forest district.

Desmidium cylindricum Grev. In the hot, dry summer of 1919 this species occurred in prodigious quantities in the Exmouth Reservoir, in such long filaments that in the water the growing mass had the appearance of a species of Spirogyra or Zygnema.

Literature Cited and Consulted.

(1) Parfitt, E.: Devon Freshwater Algae. *Transactions of the Devonshire Association,* 1886.

(2) Hiern, W. P.: *Victoria County History,* vol. i.

(3) West, W. and G. S.: A Contribution to the Freshwater Algae of the South of England. *Journal of the R.M.S.,* 1897.

(4) Joshua, W.: Notes on British Desmidiae. *Journal of Botany,* xxi. (1883) p. 290.

(5) BENNETT, A. W.: Freshwater Algae and Schizophyceae of Hampshire and Devonshire. *Journal R.M.S.*, 1890.

(6) HARRIS, G. T.: Moss Flora of Sidmouth. *Transactions of the Devonshire Association.* 1918.

(7) HARRIS, G. T.: The Desmid Flora of Dartmoor. *Journal of the Quekett Microscopical Club*, Series 2, vol. xiii. 1917.

(8) WEST, W. and G. S.: Freshwater Algae from the Orkneys and Shetlands. *Botanical Society of Edinburgh*, Nov. 1904.

(9) WEST, W. and G. S.: British Freshwater Phyto-plankton. *Proceedings Royal Society*, B, vol. 81. 1909.

(10) HARRIS, G. T.: Collection and Preservation of Desmids. *Journal of the Quekett Microscopical Club*, Ser. 2, vol. xiii, p. 15.

(11) WEST, W. and G. S. *A Monograph of the British Desmidiaceae:* The Ray Society.

(12) COOKE, M. C.: *British Desmids.* 1887.

(13) WOLLE, REV. F.: *Desmids of the United States.* Bethlehem. 1884.

(14) CLAYDEN, A. W.: *The History of Devonshire Scenery.* 1906.

(15) RALFS, J.: *The British Desmidieae.* 1848.

(16) Geological Survey Memoir.

(17) WARMING, E.: *The Oecology of Plants.* 1909.

(18) ARCHER, W.: *Desmidieae* in Pritchard's *History of the Infusoria.* Ed. 4. 1861.

CENSUS OF DESMIDS OF A TRIASSIC DISTRICT.

V.C. = Very Common. C. = Common. F. = Frequent. R. = Rare. V.R. = Very Rare.	Relative frequency in the district.	Woodbury Common.	Harcombe.	Beacon Hill.	Ring i' th' Mire.	Pools and Ditches.
Order *CONJUGATAE.*						
Family DESMIDIACEAE.						
Sub-family SACCODERMAE.						
Genus **Gonatozygon** De Bary, 1856.						
1. G. Brébissonii *De Bary* . .	R.	×		×		
2. G. Brébissonii var. laeve (*Hilse*) *W. and G. S. West* . . .	R.	×		×		
3. G. Brébissonii var. minutum *W. and G. S. West* . . .	R.	×		×		
4. G. monotaenium *De Bary* . .	R.	×				
5. G. Kinahani (*Arch.*) *Rabenh.*. .	R.	×	×	×	×	
Genus **Spirotaenia** Bréb. 1848.						
6. S. condensata *Bréb.*	F.	×	×	×	×	
7. S. fusiformis *W. and G. S. West* ($30\mu \times 4{\cdot}25\mu$). . . .	R.	×		×		
8. S. endospira (*Kütz.*) *Arch.* . .	R.	×				
9. S. truncata *Arch.* . . .	R.	×			×	
10. S. minuta *Thur.* . . .	R.	×		×		
11. S. obscura *Ralfs* . . .	R.		×	×		
12. S. trabeculata *A. Br.* . . .	V.R.			×		
Genus **Mesotaenium** Näg. 1849.						
13. M. De Greyi *Turn.*	R.	×			×	
14. M. De Greyi var. breve *W. and G. S. West*	R.	×		×		
15. M. Kramstai *Lemm.*	R.	×				
16. M. purpureum *W. and G. S. West* ($27\mu \times 8\mu$)	R.	×				
17. M. violascens *De Bary* . . .	R.	×				
18. M. macrococcum (*Kütz.*) *Roy and Bissett* ($25\mu \times 13\mu$) . . .	F.	×			×	
19. M. macrococcum var. micrococcum *W. and G. S. West* . . .	F.	×			×	

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20. M. chlamydosporum *De Bary* .	R.	×				
21. M. mirificum *Arch.* . . .	R.	×				
22. M. Endlicherianum *Näg.* (21·25μ × 8μ)	R.	×				
23. M. truncatum *W. and G. S. West* .	R.	×				
Genus **Cylindrocystis** Menegh. 1838.						
24. C. Brébissonii *Menegh.* (zygospore)	V.C.	×	×	×	×	×
25. C. Brébissonii var. minor *W. and G. S. West*	F.	×				
26. C. minutissima *Turn.* (8·50μ × 4·25μ)	R.	×	×		×	
27. C. crassa *De Bary* . . .	F.	×		×	×	
28. C. diplospora *Lund.* . . .	F.	×			×	
Genus **Netrium** Näg. 1849.						
29. N. Digitus (*Ehrenb.*) *Itzigs and Rothe*	V.C.	×	×	×	×	×
30. N. Digitus var. constrictum *W. and G. S. West*	F.	×	×	×		
31. N. interruptum (*Bréb.*) *Lütkem* (148μ to 420μ × 46μ to 55μ) .	C.	×	×	×	×	×
32. N. interruptum var. sectum *W. and G. S. West*	F.	×				
33. N. oblongum (*De Bary*) *Lütkem.* (80μ × 22μ)	V.C.	×	×	×	×	
34. N. oblongum var. cylindricum *W. and G. S. West* (100μ × 16μ) .	F.	×			×	
35. N. Nägelii (*Bréb.*) *W. and G. S. West*	R.	×	×		×	
Sub-family Placodermae.						
Genus **Penium** Bréb. 1844.						
36. P. cruciferum (*De Bary*) *Wittr.* .	F.	×	×			
37. P. cuticulare *W. and G. S. West* .	F.	×	×	×		
38. P. curtum *Bréb.*	R.	×		×		
39. P. curtum forma major *W. and G. S. West*	R.				×	
40. P. Cucurbitinum *Biss.* . . .	F.	×	×		×	
41. P. Cucurbitinum form aminor *W. and G. S. West* (40μ × 16μ) .	F.	×		×		
42. P. Cylindrus (*Ehrenb.*) *Bréb.* (zygospore)	F.	×	×	×	×	×
43. P. didymocarpum *Lund.* (21μ × 8μ)	F.	×	×		×	
44. P. exiguum *West*	R.	×			×	
45. P. exiguum forma major *W. and G. S. West*	R.	×	×			
46. P. Libellula (*Focke*) *Nordst.* . .	F.	×	×	×	×	×

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47. P. Libellula var. interruptum *W. and G. S. West*	F.	×			×	
48. P. Libellula var. intermedium *Roy and Biss.*	R.	×				
49. P. Mooreanum *Arch.*	R.	×				
50. P. minutum (*Ralfs*) *Cleeve*	F.	×	×			×
51. P. minutum forma major *Racib.*	R.	×				
52. P. minutum forma minor *Racib.*	R.	×				
53. P. margaritaceum (*Ehrenb.*) *Bréb.* (63μ × 12μ)	F.	×				
54. P. Navicula *Bréb.*	C.	×	×	×	×	×
55. P. Navicula var. crassum *W. and G. S. West*	F.		×			
56. P. polymorphum *Perty*	R.	×		×		
57. P. phymatospermum *Nordst.*	R.	×		×		
58. P. spirostriolatum *Barker*	F.	×	×		×	
59. P. subtile *W. and G. S. West*	R.	×		×		
60. P. truncatum *Bréb.*	R.	×	×	×	×	
61. P. inconspicuum *W. and G. S. West*	R.	×				
Genus **Roya** W. and G. S. West, 1896.						
62. R. obtusa (*Bréb.*) var. montana *W. and G. S. West* (33μ × 6μ)	F.	×			×	
63. R. Pseudoclosterium (*Roy*) *W. and G. S. West*	V.R.	×				×
Genus **Closterium** Nitzsch. 1817.						
64. C. abruptum *West*	F.	×	×	×	×	
65. C. abruptum var. brevius *W. and G. S. West*	R.	×			×	
66 C. acutum (*Lyngb.*) *Bréb.* (zygospore)	F.	×	×	×		×
67. C. acutum var. linea *W. and G. S. West*	F.	×			×	
68. C. acerosum (*Schrank*) *Ehrenb.*	R.					×
69. C. angustatum *Kütz.*	F.	×				
70. C. angustatum var. nov.	R.	×				
71. C. attenuatum *Ehrenb.*	F.	×				
72. C. Cornu *Ehrenb.* (97·75μ × 8μ)	R.	×		×		
73. C. Cornu var. nov.	R.	×		×		
74. C. calosporum *Wittr.* (zygospore)	V.R.	×				
75. C. costatum *Corda*	C.	×	×	×	×	×
76. C. Cynthia *De Not.*	F.	×	×	×		
77. C. Cynthia var. curvatissimum *W. and G. S. West*	V.R.	×				
78. C. Dianae *Ehrenb.*	F.	×	×	×	×	×
79. C. didymotocum *Corda*	F.	×		×	×	×
80. C. Ehrenbergii *Menegh.*	F.					×

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81. C. gracile *Bréb.* (220μ × 4·50μ) (zygospore)	F.	×	×			×
82. C. gracile var. tenue (*Lemm.*) *W. and G. S. West* . . .	C.	×	×	×	×	×
83. C. gracile var. elongatum *W. and G. S. West*	V.R.	×				
84. C. intermedium *Ralfs* . . .	V.R.	×	×	×		
85. C. incurvum *Bréb.*	R.	×				×
86. C. Jenneri *Ralfs*	F.	×	×	×		×
87. C. Jenneri var. robustum *G. S. West* (42μ × 8·5μ) . . .	V.R.	×				×
88. C. juncidum *Ralfs* (637·50μ × 20μ) (zygospore)	C.	×	×	×		×
89. C. juncidum var. brevior *Roy* .	R.	×		×		
90. C. Leibleinii *Kütz.*	F.	×	×	×		×
91. C. lineatum *Ehrenb.* (zygospore) .	F.	×	×	×	×	×
92. C. Lundellii *Lagerh.*	F.	×				
93. C. Lunula (*Müll.*) *Nitzsch.* . .	V.C.	×	×	×	×	×
94. C. Lunula var. biconvexum *Schmidle*	R.	×				
95. C. parvulum *Näg.* (zygospore) .	V.C.	×	×	×	×	×
96. C. parvulum var. angustum *W. and G. S. West*	R.	×				
97. C. praelongum *Bréb.*	V.R.					×
98. C. Pritchardianum *Arch.* . .	F.	×	×	×		×
99. C. pronum *Bréb.*	V.R.					×
100. C. peracerosum *Gay* . . .	R.	×				
101. C. porrectum var. nov. . .	V.R.	×				
102. C. Malinvernianum *De Not.* . .	R.			×		×
103. C. moniliferum *Ehrenb.* . .	R.			×		
104. C. rostratum *Ehrenb.* (zygospore) .	C.	×	×	×		×
105. C. rostratum var. brevirostratum *West*	F.	×	×	×		×
106. C. Ralfsii *Bréb.*	V.R.					×
107. C. Ralfsii var. hybridum *Rabenh.* .	R.	×				×
108. C. setaceum *Ehrenb.*	R.	×		×		×
109. C. sigmoideum *Lagerh. and Nordst.* .	V.R.			×		×
110. C. Siliqua *West*	R.	×	×	×		×
111. C. striolatum *Ehrenb.*	V.C.	×	×	×	×	×
112. C. subulatum (*Kütz.*) *Bréb.* . .	R.	×		×		×
113. C. tumidum *Johnson*	R.					×
114. C. Ulna *Focke*	R.			×		×
115. C. Venus *Kütz.*	F.	×	×	×		
Genus **Pleurotaenium** Näg. 1849.						
116. P. Ehrenbergii (*Bréb.*) *De Bary* .	V.C.	×	×	×		×
117. P. Ehrenbergii forma nov. . .	V.R.			×		
118. P. Trabecula (*Ehrenb.*) *Näg.* . .	R.	×				×

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119. P. Trabecula var. rectum (*Delp.*) *West*	R.	×				
120. P. Trabecula var. rectissimum *W. and G. S. West* . . .	R.	×				
121. P. truncatum (*Bréb.*) *Näg.* . . .	V.R.	×		×		×
122. P. truncatum var. granulatum *West*	V.R.			×		
Genus **Tetmemorus** Ralfs 1844.						
123. T. Brébissonii (*Menegh.*) *Ralfs* .	V.C.	×	×	×	×	
124. T. Brébissonii var. minor *De Bary* .	R.	×			×	
125. T. granulatus (*Bréb.*) *Ralfs* . .	V.C.	×	×	×	×	×
126. T. granulatus var. attenuatus *West*	R.	×	×	×		
127. T. laevis (*Kütz.*) *Ralfs* . . .	F.	×	×	×	×	
128. T. minutus *De Bary* . . .	R.			×	×	
Genus **Docidium** Bréb. 1844; em. Lundell, 1871.						
129. D. baculum *Bréb.*	R.	×	×	×		×
Genus **Euastrum** Ehrenb. 1832.						
130. E. affine *Ralfs*	F.	×	×	×	×	×
131. E. ampullaceum *Ralfs* . . .	R.	×	×	×		
132. E. ansatum *Ralfs*	C.	×	×	×	×	×
133. E. binale (*Turp.*) *Ehrenb.* (zygospore)	V.C.	×	×	×	×	
134. E. binale forma secta *Turn.* . .	F.	×	×	×		
135. E. binale forma hians *West* . .	F.	×		×		
136. E. binale forma Gutwinskii *Schmidle*	F.	×			×	
137. E. bidentatum *Näg.*	F.	×				
138. E. crassum (*Bréb.*) *Kütz.* . . .	C.	×	×	×		
139. E. crassum var. scrobiculatum *Lund.*	V.R.	×				
140. E. crassum var. nov. . . .	F.	×	×	×		
141. E. denticulatum (*Kirchn.*) *Gay* .	F.	×		×	×	
142. E. Didelta (*Turp.*) *Ralfs* . .	F.	×	×	×	×	
143. E. dubium *Näg.*	F.	×	×	×	×	
144. E. dubium var. Snowdoniense (*Turn.*) *West*	F.	×	×			
145. E. elegans (*Bréb.*) *Kütz.* . . .	F.	×	×			
146. E. elegans var. Novae Semliae *Wille*	R.	×				
147. E. erosum *Lund.*	V.R.	×				
148. E. gemmatum *Bréb.*	R.	×				
149. E. insulare (*Wittr.*) *Roy* . .	R.	×	×			
150. E. intermedium *Cleeve* . . .	R.			×		
151. E. montanum *W. and G. S. West* .	F.	×	×		×	

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152. E. oblongum (*Grev.*) *Ralfs* . . .	C.	×	×	×	×	×
153. E. pinnatum *Ralfs*	R.	×				
154. E. pulchellum *Bréb.*	R.	×	×			
155. E. pectinatum *Bréb.* (zygospore) .	C.	×	×	×		
156. E. pectinatum var. inevolutum *W. and G. S. West*	F.	×	×			
157. E. rostratum *Ralfs*	R.	×				
158. E. sinuosum *Lenorm.*	V.R.	×				
159. E. sinuosum var. reductum *West* .	V.R.	×				
160. E. sublobatum var. dissimile *Nordst.*	V.R.	×				
161. E. sp. nov.	V.R.	×				
162. E. verrucosum *Ehrenb.*	R.	×	×	×		
Genus **Micrasterias** Ag. 1827.						
163. M. Americana (*Ehrenb.*) *Ralfs* .	V.R.	×				
164. M. Americana var. Lewisiana *W. and G. S. West*	V.R.	×				
165. M. Americana var. recta *Wolle* .	V.R.	×				
166. M. denticulata *Bréb.*	V.C.	×	×	×		×
167. M. denticulata var. angulosa (*Hantzsch*) *West*	C.	×			×	
168. M. denticulata var. notata *Nordst.*	F.			×		
169. M. denticulata var. angusto-sinuata *Gay*	R.		×	×		
170. M. papillifera *Bréb.*	F.	×	×	×		
171. M. papillifera var. glabra *Nordst.* .	R.			×		
172. M. rotata (*Grev.*) *Ralfs*	V.C.	×	×	×		
173. M. rotata forma evoluta *Turn.* . .	R.	×				
174. M. truncata (*Corda*) *Bréb.* . . .	V.C.	×	×	×	×	
Genus **Cosmarium** Corda 1834.						
175. C. abbreviatum *Racib.*	R.	×		×	×	
176. C. abbreviatum forma minor *W. and G. S. West*	R.	×		×		
177. C. amoenum *Ralfs* (32μ × 17μ) .	R.	×		×	×	
178. C. amoenum var. mediolaeve *Nordst.*	R.	×				
179. C. anceps *Lund.*	R.	×				
180. C. annulatum *Näg.* var. elegans *Nordst.*	R.	×				
181. C. angulosum *Bréb.* var. concinnum *W. and G. S. West*	R.	×		×		
182. C. asphaerosporum *Nordst.* . . .	F.	×		×		
183. C. arctoum *Nordst.*	R.	×			×	
184. C. arctoum var. tatricum *Racib.* .	R.	×			×	
185. C. bioculatum *Bréb.*	F.	×		×		
186. C. bioculatum forma depressa *Schaarschm*	F.	×				

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187. C. bipunctatum *Börg.* . . .	R.	×				
188. C. Boeckii *Wille*	R.					×
189. C. Botrytis *Menegh.* . . .	C	×	×	×	×	×
190. C. Botrytis var. depressum *W. and G. S. West*	R.	×				
191. C. Botrytis var. gemmiferum (*Bréb.*) *Nordst.*	R.	×				
192. C. Botrytis var. subtumidum *Wittr.*	R.			×		
193. C. Botrytis var. emarginatum *Hansg.*	R.	×		×		
194. C. Brébissonii *Menegh.* (zygospore)	V.C.	×	×	×	×	×
195. C. Blyttii *Wille*	C.	×	×	×	×	
196. C. Blyttii var. Novae Sylvae *W. and G. S. West* . . .	R.	×				
197. C. coelatum *Ralfs* . . .	F.	×	×	×	×	
198. C. coelatum var. spectabile *Nordst.*	V.R.		×			
199. C. contractum *Kirchn.* . .	F.	×				
200. C. contractum var. ellipsoideum (*Elfv.*) *West*	F.	×				
201. C. contractum var. ellipsoideum forma retusa *West* . . .	F.		×		×	
202. C. crenatum *Ralfs* . . .	F.	×		×	×	×
203. C. crenatum var. bicrenatum *Nordst.*	R.	×		×		
204. C. crenatum forma Boldtiana (*Gutw.*) *West*	R.	×				
205. C. Cucurbita *Bréb.* . . .	V.C.	×		×	×	
206. C. Cucurbita forma latior *W. and G. S. West*	C.	×	×	×		
207. C. Cucumis (*Corda*) *Ralfs* . .	C.	×	×	×	×	
208. C. Cucumis var. magnum *Racib.* .	R.	×				
209. C. cymatonotophorum *West* . .	V.R.	×				
210. C. cyclicum *Lund.* . . .	V.R.	×				
211. C. cylindricum *Ralfs* . . .	V.R.	×				
212. C. cymatopleurum var. tyrolicum *Nordst.*	V.R.					×
213. C. costatum *Nordst.* . . .	R.	×				
214. C. Corbula *Bréb.* (zygospore) . .	V.R.					×
215. C. commissurale *Bréb.* var. crassum *Nordst.*	R.	×				
216. C. depressum (*Näg.*) *Lund.* . .	R.	×				
217. C. depressum var. achondrum *W. and G. S. West* . . .	F.	×				
218. C. difficile *Lütkem.* . . .	C.	×	×	×	×	×
219. C. difficile var. sublaeve *Lütkem.* .	R.	×				
220. C. exiguum *Arch.* . . .	F.					×
221. C. exiguum var. pressum *W. and G. S. West*	R.	×		×		

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222. C. elegantissimum *Lund.* forma minor *West*	F.	×	×	×		
223. C. formosulum *Hoff.* var. Nathorstii (*Boldt*) *West*	V.R.					×
224. C. galeritum *Nordst.* . . .	V.R.	×				
225. C. Garrolense *Roy and Biss.* . .	R.	×		×		
226. C. globosum *Bulnh.*	R.	×				
227. C. globosum var. minus *Hansg.* .	R.	×				
228. C. globosum forma minor *Hansg.* .	R.	×				
229. C. gonioides *W. and G. S. West* .	R.	×				
230. C. granatum *Bréb.*	R.	×				
231. C. Hammeri *Reinsch.* (54μ × 38μ)	R.	×				
232. C. Hammeri var. homalodermum (*Nordst.*) *West*	R.	×				
233. C. Hammeri var. protuberans *West*	R.	×				
234. C. Holmiense *Lund.*	R.	×				
235. C. Holmiense var. integrum *Lund.*	R.	×	×			
236. C. humile *Nordst.*	R.	×				
237. C. humile var. substriatum *Schmidle*	R.	×				
238. C. humile var. glabrum *Gutw.* .	R.				×	
239. C. homalodermum *Nordst.* . .	R.	×				
240. C. impressulum *Elfv.*	F	×		×		
241. C. inconspicuum *W. and G. S. West*	R.	×		×	×	
242. C. isthmochondrum *Nordst.* . .	R.	×				
243. C. isthmochondrum var. pergranulatum *West*	R.	×				
244. C. laeve *Rabenh.*	C.	×		×	×	
245. C. laeve var. octangularis (*Wille*) *W. and G. S. West*	C.	×				×
246. C. laeve var. septentrionale *Wille*	F.	×				
247. C. Logiense *Bissett*	V.R.	×				
248. C. margaritiferum *Menegh.* . .	F.	×	×	×		
249. C. Meneghinii *Bréb.* (zygospore) .	F.	×				×
250. C. moniliforme (*Turp.*) *Ralfs* .	R.	×				
251. C. moniliforme var. subpyriforme *W. and G. S. West*	V.R.	×				
252. C. moniliforme forma panduriformis *Heimerl.*	F.	×				
253. C. melanosporum *Arch.* (12μ × 12μ) (zygospore)	R.	×				
254. C. minimum *West* var. Boldtii .	R.	×				
255. C. Norimbergense *Reinsch.* forma depressa *West*	R.		×			
256. C. nitidulum *De Not.* (26μ × 21μ) .	R.	×		×		
257. C. notabile *Bréb.* forma media *Gutw.*	R.	×				
258. C. obliquum *Nordst.* forma major *Nordst.*	R.	×				
259. C. obliquum forma minima *West* .	R.	×				

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260. C. ochthodes *Nordst* .	F.	×		×		
261. C. ochthodes var. amoebum (*W. and G. S. West*	F.	×				
262. C. oblongum *Benn.* (60μ × 30μ)	V.R.					×
263. C. ornatum *Ralfs.*	F.	×				×
264. C. Palangula *Bréb.*	R.	×				
265. C. pachydermum *Lund.*	V.R.			×		
266. C. parvulum *Bréb.*	R.	×				
267. C. plicatum *Reinsch.* var. Hibernicum *West*	V.R.	×				
268. C. praemorsum *Bréb.*	R.		×			
269. C. prominulum *Racib.* var. subundulatum *West*	R.	×				
270. C. perpusillum *West*	R.			×		×
271. C. Portianum *Arch.*	R.	×	×	×		
272. C. punctulatum *Bréb.*	V.C.	×	×	×	×	×
273. C. punctulatum var. sub-punctulatum *Borges*	C.	×	×			
274. C. pusillum (*Bréb.*) *Arch.*	F.	×	×	×		×
275. C. pseudopyramidatum *Lund.*	F.	×				
276. C. pseudopyramidatum var. stenonotum *Nordst.*	R.	×				
277. C. pseudoconnatum *Nordst.*	R.	×	×			
278. C. pseudoexiguum *Racib.*	R.	×				
279. C. pseudarctoum *Nordst.* (zygospore)	F.	×				
280. C. pygmaeum *Arch.* (zygospore)	C.	×		×		
281. C. pyramidatum *Bréb.*	C.	×			×	
282. C. pyramidatum var. angustatum *West*	R.	×				
283. C. praegrande *Lund.*	R.			×		
284. C. Phaseolus *Bréb.* var. elevatum *Nordst.* (21μ × 21μ)	F.	×				
285. C. Phaseolus forma minor *Boldt*	F.	×				
286. C. plicatum *Reinsch.* var. hibernicum *West*	R.	×				
287. C. quadrimamillatum *W. and G. S. West*	F.	×				
288. C. quadratum *Ralfs*	R.	×			×	
289. C. quadratum var. angustatum *W. and G. S. West*	R.	×				
290. C. quadrifarium *Lund.*	R.	×				
291. C. quadratulum (*Gay*) *De Toni*	F.	×		×	×	×
292. C. Ralfsii *Bréb.*	R.	×		×	×	
293. C. Ralfsii var. montanum *Racib.*	R.	×				
294. C. reniforme (*Ralfs*) *Arch.*	F.	×	×	×	×	
295. C. reniforme var. compressum *Nordst.*	F.	×		×		×
296. C. rectangulare *Grun.*	F.		×		×	

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297. C. rectangulare var. cambrense (*Turn.*) *West*	R.	×				
298. C. retrusiforme *Wille*	R.					×
299. C. Regnellii *Wille*	F.		×			
300. C. Regnesi *Reinsch.*	C.	×	×		×	×
301. C. Regnesi var. tritum *West*	R.	×				
302. C. Regnesi var. montanum *Schmidle*	R.	×				
303. C. sexangulare *Lund.* forma minima *Nordst.*	R.	×		×		
304. C. speciosum *Lund.*	V.R.	×				
305. C. speciosum var. biforme *Nordst.*	V.R.		×			
306. C. sphalerostichum *Nordst.* (zygospore)	C.	×		×	×	
307. C. Sportella *Bréb.*	V.C.	×	×	×	×	×
308. C. Sportella var. subnudum *W. and G. S. West*	R.			×		
309. C. sphagnicolum *W. and G. S. West*	C.	×	×	×		×
310. C. sphaeroideum *W. and G. S. West*	V.R.	×				
311. C. succisum *West*	R.	×				
312. C. subarctoum *Lagerh.*	R.	×				
313. C. subcrenatum *Hantzsch.*	F.	×		×	×	
314. C. subtumidum *Nordst.*	R.	×	×			
315. C. subtumidum var. Klebsii (*Gutw.*) *West*	R.			×		
316. C. Subcucumis *Schmidle*	F.	×		×	×	
317. C. subundulatum *Wille*	R.			×		
318. C. subquadratum *Nordst.*	R.			×		
319. C. subquadrans *W. and G. S. West*	R.	×		×		
320. C. subcostatum *Nordst.*	R.		×			
321. C. subcostatum forma minor *West*	R.					×
322. C. subnotabile *Wille*	R.		×		×	
323. C. subdanicum *West*	V.R.	×				
324. C. subretusiforme *West*	R.	×				
325. C. tatricum *Racib.* var. novizelandicum *Nordst.*	R.	×				
326. C. Thwaitesii *Ralfs*	R.	×				
327. C. tenue *Arch.* (9·5μ × 8·5μ)	F.	×			×	
328. C. tumidum *Lund.*	R.			×		
330. C. tinctum *Ralfs*	C.	×	×	×	×	×
331. C. trachypleurum *Lund.*	R.	×	×			
332. C. trilobatum *Reinsch.*	R.	×				
333. C. Turpinii *Bréb.*	V.R.					×
334. C. undulatum *Corda*	R.	×		×		
335. C. undulatum var. Wollei *West*	R.					×
336. C. undulatum var. nov.	R.					×
337. C. undulatum var. minutum *Wittr.*	F.	×		×	×	×
338. C. umbilicatum *Lütkem.*	V.R.	×				
339. C. venustum (*Bréb.*) *Arch.*	F.	×	×	×		
340. C. venustum var. majus *Wittr.*	R.	×				

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341. C. venustum forma minor *Wille* (16μ × 12μ)	R.	×				
342. C. vexatum *West* (52μ × 41μ × 13μ isth.)	R.	×				
343. C. vexatum forma . . .	R.	×				
344. C. viride (*Corda*) *Josh.* . .	R.	×			×	
Genus **Xanthidium** Ehrenb. 1837.						
345. X. aculeatum *Ehrenb.* . . .	R.	×	×			
346. X. antilopaeum (*Bréb.*) *Kütz.* (zygospore)	R.	×	×			
347. X. armatum (*Bréb.*) *Rabenh.* . .	V.C.	×	×	×		
348. X. armatum var. irregularis *West* .	V.R.		×			
349. X. concinnum *Arch.*	V.R.	×				
350. X. Smithii *Arch.*	V.R.	×				
351. X. variable (*Nordst.*) *W. and G. S. West*	V.R.	×				
Genus **Arthrodesmus** Ehrenb. 1838.						
352. A. bifidus *Bréb.*	R.	×				
353. A. convergens *Ehrenb.* . . .	V.R.	×				
354. A. crassus *W. and G. S. West* .	R.				×	×
355. A. controversus *W. and G. S. West*	R.	×				
356. A. Incus (*Bréb.*) *Hass.* (zygospore)	F.	×	×			
357. A. Incus var. Ralfsii *W. and G. S. West*	F.	×				
358. A. Incus var. indentatus *W. and G. S. West*	F.	×			×	
359. A. Incus var. subquadratus *W. and G. S. West*	R.				×	
360. A. Incus forma minor *W. and G. S. West*	R.	×			×	
361. A. Incus forma perforata *Schmidle*	V.R.				×	
362. A. subulatus var. subaequalis *W. and G. S. West*	R.	×				
363. A. tenuissimus *Arch.*	R.	×				
364. A. triangularis *Lagerh.* forma triquetra *West*	R.					×
365. A. trispinatus *W. and G. S. West* .	V.R.	×				
365* A. octocornis *Ehrenb.*	R.	×				
						×
Genus **Staurastrum** Meyen 1829.						
366. S. aculeatum *Men.*	F.	×				
367. S. alternans *Bréb.*	F.	×	×			
368. S. apiculatum *Bréb.*	F.	×	×	×		
369. S. asperum *Bréb.*	R.	×				

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370. S. Bieneanum *Rabenh.* var. ellipticum *Wille*	F.	×	×	×		
371. S. brevispinum *Bréb.* (zygospore) .	F.	×				
372. S. brevispinum var. inerme *West* .	R.	×				
373. S. brevispinum forma retusa (*Borge*) *West*	R.	×				
374. S. brachiatum *Ralfs* . . .	R.	×				
375. S. Capitulum *Bréb.* . . .	F.	×	×	×		
376. S. controversum *Bréb.*	R.	×		×		
377. S. coarctatum *Bréb.* . . .	R.	×				
378. S. cuspidatum *Bréb.* . . .	R.	×				×
379. S. cyrtocerum *Bréb.* . . .	F.	×			×	
380. S. dilatatum *Ehrenb.* . . .	R.	×		×		
381. S. dilatatum var. hibernicum *W. and G. S. West*	R.	×				×
382. S. dispar *Bréb.*	V.R.	×			×	
383. S. Dickiei *Ralfs*	R.	×				
384. S. dejectum *Bréb.* (zygospore) .	C.	×	×	×		
385. S. dejectum var. convergens *Wolle*.	F.	×				
386. S. furcigerum (*Bréb.*) . . .	F.	×				
387. S. gracile *Ralfs*	F.	×				×
388. S. gracile var. nanum *Wille* . .	C.	×				
389. S. granulosum (*Ehrenb.*) *Ralfs* .	R.	×				
390. S. granulosum forma connexa *West*	R.	×				
391. S. hirsutum *Bréb.*	C.	×	×	×	×	
392. S. inconspicuum *Nordst.* . .	F.	×				
393. S. lanceolatum *Arch.*	R.	×				
394. S. margaritaceum *Meneg.* . .	F.	×		×	×	
395. S. O'Mearii *Arch.*	F.	×		×		
396. S. Meriani *Reinsch.*	F.	×	×	×	×	
397. S. monticulosum *Bréb.*	R.	×				
398. S. muricatum *Bréb.*	R.	×				
399. S. muticum *Bréb.*	R.	×	×			
400. S. orbiculare *Ralfs* var. Ralfsii *W. and G. S. West* (zygospore) .	F.	×	×	×	×	
401. S. orbiculare var. depressum *Roy and Biss.*	F.	×				
402. S. pilosellum *W. and G. S. West* .	R.	×				
403. S. polymorphum *Bréb.* (zygospore)	F.	×			×	
404. S. polytrichum *Perty* . . .	C.	×	×	×		
405. S. pileolatum *Bréb.*	R.				×	
406. S. punctulatum *Bréb.* (zygospore) .	V.C.	×	×	×	×	×
407. S. punctulatum var. Kjellmanni *Wille*	C.		×	×		×
408. S. punctulatum var. pygmaeum (*Bréb.*) *West*	R.			×		
409. S. punctulatum var. striatum *West*	R.	×		×		
410. S. Reinschii *Roy*	F.	×		×		
411. S. rugulosum *Bréb.*	R.	×				

V.C. = Very Common. C. = Common. F. = Frequent. R. = Rare. V.R. = Very Rare.	Relative frequency in the district.	Woodbury Common.	Harcombe.	Beacon Hill.	Ring i' th' Mire.	Pools and Ditches.
412. S. sexcostatum *Bréb.*	F.	×				
413. S. striolatum (*Näg.*) *Arch.*	F.	×	×	×	×	×
414. S. saxonicum *Reinsch.*	R.	×				
415. S. suborbiculare *W. and G. S. West*	R.	×				
416. S. subcruciatum *Cooke and Wills*	R.					×
417. S. teliferum *Ralfs* (zygospore)	C.	×	×	×	×	
418. S. tetracerum *Ralfs*	R.	×				
419. S. tumidum *Bréb.*	R.	×				
420. S. turgescens *De Not.*	R.	×	×			
Genus **Sphaerozosma** Corda 1835.						
421. S. vertebratum (*Bréb.*) *Ralfs*	R.	×				
422. S. pygmaeum *Rabh.*	R.				×	
Genus **Hyalotheca** Ehrenb. 1840.						
423. H. dissiliens (*Smith*) *Bréb.*	V.C.	×	×	×	×	×
424. H. dissiliens var. hians *Wolle*	C.	×				
425. H. mucosa (*Dillw.*) *Ehrenb.*	F.	×		×	×	×
Genus **Desmidium** Ag. 1824.						
426. D. Swartzii *Ag.*	F.	×				
427. D. cylindricum *Grev.*	F.	×				×
Genus **Gymnozyga** Ehrenb. 1840.						
428. G. moniliformis *Ehrenb.*	F.	×		×		×
Genus **Spondylosium** Bréb. 1844.						
429. S. papillatum *W. and G. S. West*	V.R.	×				

THE MICROSCOPICAL STRUCTURE OF LICHENS.

By Robert Paulson, F.L.S., F.R.M.S.

(*Read June 8th,* 1920.)

Before considering the microscopic details of the lichen thallus it may prove of some advantage to preface these remarks with a few statements regarding lichens as they appear in their natural habitats, for some of them are sufficiently conspicuous to claim our attention by reason of size, form or colour. There are, for instance, the "beard lichens" *Usnea barbata* and *Usnea plicata*, which frequently hang in long tangled festoons from the trunks and branches of trees in pine forests in upland or mountainous districts. A similar species, *Usnea florida*, stands erect from the substratum, and closely resembles a miniature shrub; they all belong to the fruticose or shrub-like form of the lichen thallus. The yellow "crottle" *Xanthoria* (*Physcia*) *parietina*, known by sight to all of us, often covers, with bright orange patches, large portions of the roofs and walls of farm buildings. It has a leaf-like appearance, and serves as a good example of the foliose thallus; it is dorsiventral in structure, the fruticose lichen being radial. The third form, the crustose lichen, also dorsiventral, develops as a crust, which in some species is of considerable thickness, while in others the thallus is so attenuated that it resembles a stain upon wood, stone or soil, whichever may be the substratum (**6**).

The three forms of thallus, crustose, foliose and fruticose, exhibit stages of evolution; the crustose, which in its simplest state consists of a loose mass of tangled filaments enclosing green cells, represents a low stage, while some of the highly developed fruticose lichens represent the highest point of development. There is no straight line of development along which the lichens have travelled, for all three forms appear in certain of the larger families, as in the *Parmeliaceae*, the *Physiaceae* and the *Cladoniaceae.*

Reproductive organs occur upon the thallus. On the fruticose form they are produced at the end or side of the branches; on the foliose and crustose forms they occur upon the upper surface either in the centre or on the edge of the thallus. These organs are sometimes disc-shaped and are known as *apothecia*, or they are flask-shaped bodies called the *perithecia*, the latter often being immersed in the thallus or even in small depressions of the rock. The pits have been caused by the action of the lichen upon the stone.

Lichens are divided into two great series according to the form of the reproductive organs; those with the open disc (apothecium) belong to the *Gymnocarpeae*, and those with more or less closed perithecium are included in the *Pyrenocarpeae.* It is not proposed to describe the microscopic structure of the reproductive organs just mentioned, for the time at our disposal will not admit of this; but a short descripton of a non-vegetative method of reproduction of the green cells, described for the first time quite recently, will be given later on (**3**).

Lichens may be regarded from quite another standpoint; they are when moist either gelatinous, like the well-known alga Nostoc, or non-gelatinous. These respectively represent two entirely different types of structure as regards the thallus, the former having the green cells, *gonidia*, scattered evenly through the thallus, while in the latter they form a definite layer closely under the upper surface.

The lichen selected for more detailed description is *Cladonia digitata*, a dorsiventral, non-gelatinous plant.

It was in 1868 that Schwendener announced his view that a lichen consists of two distinct organisms, a fungus and an alga, growing in close relationship (**5**). In a remarkably short time, less than a decade in fact, this view was generally accepted.

The fungus consists of fine septate hyphal threads of from 3 to 4 microns in diameter, these being greatly modified according to the position they occupy in the thallus. The gonidium (algal cell) of *Cladonia digitata* is spherical in shape and bright green in colour, and belongs to the *Chlorophyceae*; it is common to a large number of foliose and fruticose lichens (Pl. 4, fig. 1).

There is no need for cutting sections during the preliminary examination of the constituents of a lichen thallus, for it is sufficient if one places a small portion upon a glass slip, and pounds it while there with the flat blade of a pocket-knife. The alga and the fungus will be separated, and owing to the minute size of the algal cells they will be uninjured, and can be examined as separate objects. A 1/6-in. or 1/8-in. objective will be required for this work.

Before satisfactory sections can be cut, it is necessary to fix the material, and for this purpose a weak chromo-acetic fixing medium is used, allowing the material to remain in the solution for at least twenty-four hours. After the fixation, a thorough washing is given, and this is continued for from two to three hours. It has not been found that fixing by using successive strength of alcohol produces equally good results. Fixed material is passed into paraffin wax in the usual way, and sections are cut with a Cambridge "rocker" microtome.

For staining the sections, Haidenhain's iron-alum-haematoxylin is the most generally useful; Bonney's triple stain, methyl-violet-pyronin and orange G. acetone, differentiates remarkably well (**1**). Cyanin and erythrocin have been recommended for this work, but the differentiation is not altogether satisfactory.

After staining, all sections were formerly mounted in Canada balsam, but some are now put up in glycerine, for by this method the cell wall is often rendered remarkably clear.*

A transverse section of the thallus of *Cladonia digitata* exhibits a series of parallel layers, the uppermost of the series being the upper cortical layer. The next in order is the gonidial layer, which is followed by the medulla and the lower cortical layer (Pl. 4,

* I am glad of this opportunity for expressing my indebtedness to Mr. J. H. Pledge for the help he has given me by making photo-micrographs from the preparations that are being used to illustrate the latter part of my communication. By means of them I am able to explain more clearly the conclusions that I have arrived at after the examination of a considerable number of species of the different genera of lichens. Most of the photomicrographs are × 1,000 upon the lantern slide.

fig. 1). In the fruticose thallus the first three of these are arranged in concentric circles.

The upper cortex consists of specially modified hyphae. They have very thick walls and are cemented together, forming a false tissue. In some species the upper cortex is continuous, in others it is broken, so that the next or gonidial layer is exposed.

The gonidial layer consists of the cells of an alga interspersed within the meshes of hyphae; some of them are perfectly free, others are firmly attached, and again some are completely surrounded by a plexus of hyphae; but the hyphal threads differ from those of the upper cortex, for the cell wall is comparatively thin, and the extremities of the branches swell out into a pyriform shape, and thus afford a larger surface for contact with the algal cells.

The algal cell (Pl. 4, fig. 2) when fully developed is spherical, except when subject to pressure from other cells during active growth; it has a diameter of from 10 to 15 microns. It contains a single bright-green chloroplast which lines the whole of the cell wall; the nucleus is large and central, and there is on the circumference of the chloroplast a small body surrounded by a light area. The cytoplasm is finely reticulated. This may account for the fine network of hyphae which is said to sometimes surround the chloroplast after entering the cell (2) (4). For a thorough examination of such an algal cell it is necessary to employ a 2-mm. oil-immersion objective. The central body has often been referred to by other authors as a pyrenoid, but repeated examination after various methods of staining led to a decision in favour of the nucleus. The body resisted the stain when heated nearly to dryness on the slide with acid-fuchsin followed by immersion in a warm concentrated solution of potassium bichromate.

There is much lack of precision in papers and textbooks as to the name of the alga that is common to so many lichens. It is often described as Protococcus, Pleurococcus, Cystococcus. Pleurococcus of most authors was proved by Wille, 1913, who had examined the original material of Agardh in the Museum of Lund, to be no other than Protococcus Ag. so that Pleurococcus cannot now be used. Cystococcus Näg. is now Chlorococcum, as it has been proved to produce abundant motile swarm-spores as well as aplanospores. The gonidium we are considering could not be Protococcus or Pleurococcus (old style) because these both divide vegetatively and the gonidium of our type does not divide in this manner. I ventured two years ago to suggest that the gonidium in question is a species of Chlorella, for the process in the formation of daughter cells—reduced zoogonidia—in free Chlorella and in the gonidium is to all appearances precisely similar (7). The late Prof. West examined some of the material I was working on, and in his opinion "the alga is nearer to Chlorella than anything else" he was acquainted with.

When the investigation of the constituents of the lichen thallus was planned with Somerville Hastings, its purpose was that of accumulating data bearing on the frequency of the penetration of the algal cells by the fungus hyphae, for it had been asserted by recent authors in America and Russia that the fungus of the lichen thallus is parasitic upon the alga, and in support of their statements, the penetration of living algal cells by the fungus was the most important (3).

Figures and photomicrographs which have been published for the purpose of demonstrating actual penetration of living algal cells are by no means convincing. In many cases they indicate defects in the methods of illumination.

In the investigation no single instance was found of what could be regarded as a clear case of penetration, such as those which have been figured (2.) Elfving writing in 1913 says: "The formation of haustoria upon the hyphae, which grow into the lumen of gonidial cells as represented in popular textbooks, was extraordinarily rare; in my material only on a single occasion have I seen such a haustorium."

It is contended that before a theory relating to the parasitic nature of the fungus of the lichen thallus can be firmly established, on the basis of penetration, an approximation of the extent to which penetration takes place must be made. Penetration possibly takes place occasionally, but until this condition is proved to be the rule rather than the exception, the theory of parasitism has little to support it.

The question of penetration can be decided by the microscope alone, and for this purpose all the help that microscopical technique can afford is required. The objects to be observed are minute—a sphere with a diameter of from 10 to 12 μ, and a thread 3 to 4 μ thick. Such objects give images that vary considerably according to the method of illumination and the focusing, but the solution is not beyond the reach of careful manipulation. From the investigation it is inferred that there is no doubt whatever that actual penetration of the living cell very rarely occurs where the alga is Chlorella (Cystococcus of most authors); the case of lichens with blue-green algae, *Cyanophyceae*, have not yet been fully considered; nor have those where the alga is Trentepolia, which is of an orange colour.

It has been generally assumed that the gonidia of lichens, described above, increase in number by vegetative cell division, and that spore formation takes place only when the gonidia have been isolated from the thallus and subjected to cultural methods. This assumption has probably arisen from the fact that in one of the most important textbooks on Fungi, a book used throughout the world, the following statement is found: "In one point the Fungus is the superior in the common household; *it alone produces spores*, the alga with few exceptions remains barren as long as it is combined with the Fungus." The only exception given in this case is that of *Synalissa symphorea*, a lichen with a blue-green alga. It is now possible to show definite stages in the formation of spores within algal cells while they are components of the lichen thallus. The original protoplast of the cell divides into 4, 8, 16 or 32 masses. The most common numbers that have been found are 8 and 16. These masses soon develop a cell wall, and within a short period they resemble in all respects but size the mother cell, which rapidly becomes diffluent, and thus the daughter gonidia escape (Pl. 4, fig. 1).

A great deal of what has been said is not in agreement with the opinions of authors, but the claim is made upon the evidence of preparations and an interpretation thereof as it presents itself after a considerable amount of time devoted to the subject.

There is an important factor to bear in mind in that the majority of lichenologists have devoted their energies to the classification and description of these puzzling organisms very often to the exclusion of research into their microscopic structure. This field of research is open to the worker who will bring to bear on the subject the necessary skill in microscopical manipulation.

Summary of Results.

1. The gonidium of a large number of British lichens is most probably a species of Chlorella.
2. The gonidium does not divide vegetatively, but sporulation takes place within the algal mother cell while it forms a constituent of the lichen thallus.
3. The sporulation is similar to that which takes place within free Chlorella cells.
4. Penetration of living gonidia by hyphae seldom, if ever, takes place.
5. The percentage of dead empty gonidial cells within the lichen thallus is as a rule quite small.
6. In a well-developed lichen the gonidia have all the appearance of being thoroughly healthy.

Bibliography.

(1) Bonney, Victor : A New and Rapid Triple Stain, *Archives Middlesex Hospital*, vol. xiii. 1908.
(2) Danilov, A. N. : Ueber das gegenseitige Verhältnis zwischen den Gonidien und dem Pilzkomponenten in der Flechtensymbiose, *Bull. Jard. Imp. Bot. Pétersbourg*, tom. x., livr. (2) 1910. Translation in *Journal of Botany*, vol. lvi. June 1918.
(3) Paulson, R., and Hastings, Somerville : Relation between the Alga and Fungus of a Lichen, *Journ. Linn. Soc.*, *Botany*, vol. xliv. March 1920.
(4) Peirce, G. I. : The Nature of the Association of Alga and Fungus in Lichens, *Proc. Calif. Acad. Sci. Bot.*, vol. i. 1899.
(5) Schwendener, S. : *Die Algentypen Flechtengonidien.* Basel, C. Schultze. 1869.

(6) SMITH, A. LORRAIN: *A Monograph of the British Lichens*, pp. 7–23, Part 1. 1918.

(7) WEST, G. S.: *Cambridge Botanical Handbooks*, Algae, vol. i. 1916.

DESCRIPTION OF PLATE 4.

1. *Cladonia digitata.* Transverse section of a squamule of the thallus; (*a*) upper cortical layer; (*b*) gonidial layer; (*c*) medulla; (*d.g.*) group of daughter gonidia; (*m.g.*) mature gonidium. × 400.

2. *Cladonia digitata.* Isolated gonidium; (*c.w.*) cell wall (light area); (*c*) chloroplast, reticulated cytoplasm; (*n*) nucleus; (*p*) peripheral body in the centre of a light area. ×4,000.

NOTICES OF BOOKS.

A GUIDE TO THE IDENTIFICATION OF OUR MORE USEFUL TIMBERS. being a manual for the use of students of Forestry. By Herbert Stone. viii + 52 pages + 3 plates. $8\frac{1}{2} \times 5$ inches. (Cambridge: At the University Press, 1920. Price 7*s*. 6*d*. net.)

IN the preparation of this *Guide* for the use of students of Forestry, the author has endeavoured to provide information on certain points which is not easily accessible elsewhere. The timbers of some thirty broad-leaved trees and ten conifers are dealt with, and in the choice of characteristics every effort has been made in favour of points of difference in kind, those of degree, such as colour, hardness, weight, etc., not being found reliable in differentiating the species of timber. One of the objects of the author is to train the student's powers of observation in recognising the essential characters and by this means discriminating between one or other species of timber. To this end the description of each species is followed by a table, giving the timbers with which the one under consideration may be confused, and those features by which it may be distinguished. In the introductory note some useful hints are given in methods of observation. Artificial keys are provided covering the woods dealt with in the course and the student is advised to familiarise himself with their use. The three beautiful collotype plates represent at a uniform magnification of 50 diameters sections of wood where the critical details can only be made out by the aid of the microscope. The *Guide* cannot fail to be of much use both to the student and also to the worker in wood research laboratories.

MINERALS AND THE MICROSCOPE. By H. G. Smith, A.R.C.S., B.Sc., F.G.S. xii + 116 pages + 12 plates, coloured frontispiece and 33 figs. in text. $7\frac{1}{4} \times 4\frac{3}{4}$ inches. (London: Thomas Murby & Co., 1919. Price 5*s*. net.)

The author's experience as a teacher has led him to the conclusion that the initial difficulties of the student of petrology are not always met by the instruction provided in a course of lectures. To supply such a need, and to serve as a companion in the practical work of such a course, is the aim of this little book. It has been found necessary to assume that the student has already acquired a knowledge of elementary physics and crystallography. To the working microscopist who has devoted his attention to the study of rock sections, the little book will be very helpful indeed, and can be recommended. The book is divided into two sections: the Optical Properties of Minerals, and the description of the Common Rock-forming Minerals. The latter part is illustrated by twelve plates which exhibit the facies of the minerals as found in rock-sections. Many practical hints given in the first part will prove very useful to the student in working out the optical properties of the minerals under examination. Pages 93–97 are devoted to the "shadow" method of determining the refractive indices of isolated fragments. This method has the advantage that only a very small quantity of the mineral is required. The association of rock-forming minerals is considered in the closing pages—"Hints on Petrology."

The publishers also issue a series of micro-slides representative of the various rocks, and such sections of minerals for the polarising microscope as illustrate the methods of determination described in the first part of the book.

(1) The Mycetozoa: A Short History of their Study in Britain; an account of their habitats generally; and a list of species recorded from Essex. By Gulielma Lister, F.L.S. (*Essex Field Club Special Memoirs*, vol. vi.) vi + 54 pages, frontispiece. $8\frac{1}{2} \times 5\frac{1}{2}$ inches. (Stratford, Essex: The Essex Field Club; London: Simpkin, Marshall & Co., Ltd., 1918. Price 3*s*. net.)

(2) Guide to the British Mycetozoa exhibited in the Department of Botany. Fourth edition. 62 pages; 51 figs. in text. $8\frac{1}{2} \times 5\frac{1}{2}$ inches. (London: Brit. Mus. Nat. Hist., 1919. Price 1*s*. net.)

Our excuse for drawing attention to these two little books, which are probably quite familiar to the worker in the study of Mycetozoa, is the need of lending a helping hand to the junior members of our Club. Many have not taken up any definite branch of work in microscopy for lack of such guidance. Mr. Hilton has on several occasions drawn attention to the interest and beauty of the objects of his study.

In the first book mentioned Miss Lister has issued the material of two Presidential addresses before the Essex Field Club. The first part gives an interesting historical account of the study of Mycetozoa in Britain, from John Ray, who refers to one of our commoner forms in his *Synopsis of British Plants* (1696), to the classic monograph by Mr. Arthur Lister: *Descriptive Catalogue of the Mycetozoa.* The second part, dealing with the habitats of the Mycetozoa generally, cannot fail to be of great service in the search for these organisms. This section is followed by a table giving some of the habitats of Mycetozoa, with lists of species associated with each. The information contained in this section and table is just of that kind which is helpful to the student who has taken up the study of these organisms for the first time, and is on the outlook for specimens.

The *Guide to the British Species of Mycetozoa*, for which we are indebted to the courtesy of the Trustees of the British Museum, has now reached its fourth edition. The opportunity has been taken of carefully revising the text, and at the same time bringing the nomenclature of the species into conformity with the International Rules. Nearly three dozen species have been recorded as British since the date of the last edition of the *Guide.*

With the aid of these two inexpensive books any member of our Club might lay the foundation of a very useful study of some of the problems of biology.

An Introduction to the Study of Cytology. By Prof. L. Doncaster, Sc.D., F.R.S. xiv + 280 pages + 24 plates and 31 figs. in text. $8\frac{3}{4} \times 5\frac{3}{4}$ inches. (Cambridge: At the University Press, 1920. Price 21*s.* net.)

Cytology has in the past been very largely a morphological and descriptive science; its aim has been to observe the structure of cells, to determine the parts of which they are composed, and to describe the changes through which they pass in the various phases of rest and division. But inevitably the study of morphology leads on to that of function, and there arises in the student's mind a continual demand for explanation of morphological fact either in terms of function or by means of the still more fundamental laws of physics and chemistry. The subjects, however, that have chiefly occupied the attention of cytologists during the last few years have been the material basis of hereditary transmission and of the determination of sex. Towards the solution of both these problems Prof. Doncaster has contributed very largely.

The plan of this book follows that of the course of lectures given by the author at Cambridge, and its purpose is to interest the student in the subject by showing some of the ways in which cytological investigation is related to the fundamental problems of biological research. A statement of the more important facts relating to the subject is given, but the author's predilection has led him to devote considerable attention to those sides of the subject in which he is chiefly interested, especially the cytological basis of hereditary transmission and of sex determination. The subject of parthenogenesis is treated at length, and the author has drawn upon his own interesting researches in this subject. This chapter naturally leads to one devoted to Artificial Parthenogenesis, where an account is given of the methods adopted and of the results obtained; also the bearing of these results on cytological study in the future, as important advances may be anticipated in our knowledge of the physiological or functional aspects of Cytology. The book is fully illustrated, and an attempt has been made to employ as far as possible copies of original figures, and only to make use of diagrams where they appeared necessary. There is a bibliography and an index.

Since the publication of this book we have had to deplore the loss to science by the death of the author, who passed away at an early age after achieving, by his brilliant researches and devotion to science, a position of notable distinction in the subject of his choice.

ROLL OF HONOUR.

The following Roll includes the Members of the Club who have been on Service during the War.

OPTIME DE PATRIA MERITI.

Rank and Name.	Unit.	Honours.
Lt. K. F. Barratt . . .	Essex Regt.	Killed in action.
Lt. G. F. Hook . . .	Border Regt.	Killed in action.
Cpl. B. A. Adams . . .	R.E.	
Instr.-Comdr. M. A. Ainslie .	R.N.	
Capt. W. McD. Allardice .	Res. of Officers.	O.B.E.
Lt. E. J. Barnard . .	Notts. and Derby.	Mention.
Lt. T. F. Barratt . . .	Croix Rouge.	Croix de Guerre.
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Cpl. F. E. Cocks . . .	28th London Regt.	D.C.M.
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Lt. M. Davidson (Rev.) .	R.G.A.	Mention.
Pte. L. S. Dimsdale . .	London Scottish.	Wounded.
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Sgt. N. L. Gillespie . .	Middlx. Regt.	'14-'15 Star.
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Bombr. H. O. Green . .	R. F.A.	
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Capt. A. F. C. Pollard . .	R.A.F.	
Writer E. W. Ramsay . .	R.N.	
Rflm. D. H. Shuckard . .	K.R.R.	
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Lt. P. H. Trotman . .	R.F.A.	
Sgt. J. Turnbull . . .	79th Canadian Regt.	
Capt. J. F. D. Tutt . .	R.A. Vet. Corps.	
Cpl. H. Whitehead . .	R.A.M.C.	
Pte. C. L. Withycombe . .	13th London Regt.	
Lt. C. Worssam . . .	34th Sikh Pioneers	
Lt.-Gen. Sir N. Yermoloff .	Russian Mil. Attaché.	K.C.B. Mil. Div.

FIFTY-FOURTH ANNUAL REPORT.

Taking into consideration the difficulties of the past year, the Committee feels that the report it presents is, on the whole, a satisfactory one. During the year 1919, thirty-seven new members were elected, three have resigned and ten members have been removed by death. Amongst these the loss of Sir Frank Crisp, a former Vice-President, Prof. G. S. West, lately elected an Honorary Member, and Mr. John Hopkinson, late Secretary to the Ray Society, is deplored not only by the Club, but by the world of science. We regret also to record the death of Mr. Alfred George, Librarian to the Club since 1917. The number of members on December 31st was 464. The most important event to record has been the removal to our new quarters at 11, Chandos St., Cavendish Sq., W.1. This change, arrived at after much careful consideration, has not been what the Committee desired, involving, as it does, separation from the Library, and inconvenience, particularly on Gossip evenings and in the use of the Cabinet, thus curtailing the usefulness of the Club very considerably.

The principal communications during the year have been as follows:

Papers read and Communications made to the Q.M.C. to the End of the Year 1919.

January 14th.—Dr. J. R. Leeson: Insect-eating Plants. Mr. E. M. Nelson: A New Form of Micro-polariscope.

February 11th.—Presidential Address: Adaptation of Plants to their Environment.

March 11th.—Mr. C. D. Soar: The Water-mite: *Oxus plantaris.* Mr. George West: *Amphora inflexa:* a Rare Marine Diatom.

April 8th.—Mr. E. K. Maxwell: The Amateur Microscopist in War-time.

May 13th.—Dr. H. Hartridge: Microscopical Illumination. Mr. E. M. Nelson: The Greenough Binocular; Pollen as a Polariscope Object; The History of the Club's Premises.

June 10th.—Mr. F. Martin Duncan : Studies in Marine Zoology. Mr. E. M. Nelson : An Observation of Differential Staining of the Flagella of Bacteria.

October 14th.—Dr. J. R. Leeson : Toothwort (*Lathraea squamaria*).

November 11th.—Dr. G. H. Rodman : Some Floral and Faunal Remains of the Coal Measures.

December 9th.—Mr. D. J. Scourfield : Nannoplankton and its Collection by Means of the Centrifuge. Mr. E. M. Nelson : Capped Eyepieces.

The Hon. Curator reports that only twelve slides were added to the Cabinet during the past year. Unfortunately, so far, only standing accommodation has been provided for the slide cupboard in our present premises, with no room for handling the slides, etc.; in consequence the loan of slides has had to be suspended until some better accommodation can be arranged. Advantage has, however, been taken to steadily push forward the revision of the collections and preparation of the new catalogue, and it is hoped that during the coming year our rather extensive collection of anatomical and diatomaceae slides will be dealt with, which will complete this rather arduous task. The collections generally are being brought up to date as regards classification : many Sections, which had grown rather unwieldy, have been recast, and a large number of defective preparations have been thrown out, so as to improve the general standard. Although the Club is to be congratulated on possessing a fairly representative collection, many gaps are painfully conspicuous, which can only be filled up by the generosity of members; and it is to be regretted that members do not present duplicates of their mounting, as was the practice in the early days of the Club.

The Report of the Hon. Secretary of the Excursion Sub-Committee is satisfactory in spite of high fares and reduced railway facilities. At the ten excursions held during the year, the average attendance was 21·9, the second highest in the Club's record. The first excursion, thanks to the kindness of the Royal Botanical Society, was made to their Gardens, Regent's Park, and was as usual well attended, thirty-six being present. The weather being cold, the captures were below the average, comprising only a few Hydra, two species of Polyzoa, a number of free-swimming Rotifers as well as Melicerta and a few Infusorians of the Folliculina group. The Chingford excursion on April 26th was not so fortunate, the favourite pools being almost dry. On May 10th, by the kind invitation of our President, Dr. Rendle, F.R.S., the Botanical Section of the British Museum, Cromwell Rd., was visited, when the President exhibited and described some of the unique treasures of the Collection. A most successful excursion to Greenford and Hanwell on May 24th was enjoyed by only fifteen members, who took *Lophopus crystallinus* in great abundance, *Plumatella repens*, *P. fungosa* and a good selection of Desmids. Staines was visited on June 10th, but two of the favourite ponds were dried up and the large pond on the Common did not yield anything remarkable. On June 28th, for the first time since 1913, the East London Waterworks were visited, but owing to the cleaning of the reservoirs and the removal of the filamentous algae and other water plants from the margins, some of the good things usually taken here were not found. Only ten members participated in the successful excursion to Northwood and Ruislip on July 12th, when *Fredericella sultana* and Paludicella were found in abundance. A party of twenty-five, on July 26th, was well rewarded at the Richmond Park excursion by good finds at the favourite ponds. The Eagle Pond, Snaresbrook, and the Lake, Highams Park, were visited on August 16th, when *Volvox aureus* and three species of Polyzoa were taken. The last excursion of the season was to Hampton Court, on September 6th. After crossing the Thames the pond inside the field in which *Plumatella repens* had formerly been found in abundance was dried up; some statoblasts, however, were gathered from a damp spot on the bottom, and some free-swimming Rotifers, including *Noteus quadricornis*, were taken. In the large pond, the Round Pond and the Long Water, *Ophridium versatile*, three species of Polyzoa and a good selection of Desmids, as well as Melicerta, Stephanoceros and Floscularia, and free-swimming Rotifers including Pterodina, were collected.

On the kind invitation of Dr. and Mrs. Leeson, the party was entertained to tea at Clifden House, Twickenham, when the rareties in the garden and in the library were duly shown and described by the genial doctor, and a vote of thanks to our host and hostess was accorded on the motion of Mr. Peter Lawson, thus bringing to a close a most enjoyable excursion.

Thanks to the kindness of the President, Dr. Rendle, F.R.S., the Library has been accessibly placed, for the time being, in the Botanical Gallery at the British Museum, Cromwell Rd., and the Librarian, Mr. Todd, has kindly volunteered to attend for the exchange of books for members, in the afternoon of the first Saturday in each month, from 2 till 4 p.m.

The following books have been added to the Library during the year :

MONOGRAPH OF BRITISH LICHENS.
By Annie Lorrain Smith. *Presented by the Trustees of the British Museum.*

THE FORAMINIFERA OF THE SPEETON CLAY OF YORKSHIRE.
Extracted from *The Geological Magazine* and *presented by the author*, DR. R. L. SHERLOCK, A.R.C.S., F.G.S.

Also the following Memoirs, Reports and Proceedings :

Academy of Natural Science, Philadelphia.
American Microscopical Society.
British Association Report, 1917, 1918
California, University of.
Essex Naturalist.
Geologists' Association.
Illinois State Laboratory, Natural History.
Indian Museum, Calcutta.
Missouri Botanical Gardens.
Northumberland, Durham, Newcastle-on-Tyne Natural History Society.
Notarisia.
Nyt Magazine for Naturvidenskaberne.
Philippine Journal of Science.
Photomicrographic Society.
Quarterly Journal of Microscopical Science.
Royal Microscopical Society.
Royal Photographic Society.
Royal Society of London.
Royal Society of New South Wales.
Smithsonian Institute.
United States Natural Museum.
Victorian Naturalist.

It is with great regret that the Committee learns that, owing to continued disability, Mr. C. F. Rousselet is compelled to withdraw from active participation in the affairs of the Club.

In conclusion, the Committee again desires to express its thanks, and those of the members, to the various officers who have so loyally conducted the affairs of the Club in a difficult year, often at the expense of considerable time and trouble.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

For the year ending December 31st, 1919.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance from 1918	145	3	5	By Rent	50	12	6
,, Subscriptions	180	10	5	,, Expenses of *Journal*	180	0	9
,, Dividends	13	17	0	,, Postages, etc.	6	9	1
,, Sales of *Journal*	7	12	6	,, Printing and Stationery	11	16	0
,, Advertisements	2	5	0	,, Attendant	4	12	8
				,, Petty Expenses	1	2	6
				,, Books and Slides	15	3	0
				,, *English Mechanic*	9	1	6
				,, Removal	14	2	0
				,, Balance in hand	56	8	4
	£349	8	4		£349	8	4

INVESTMENTS.

	£	s.	d.
$2\frac{1}{2}$ per cent. Consols	334	1	6
Metropolitan Water Board Stock	100	0	0
Metropolitan Stock	100	0	0
$2\frac{1}{2}$ per cent. Annuities, 1905	100	0	0

We have examined the above Statement of Income and Expenditure and compared the same with the Vouchers in the possession of the Treasurer, and have verified the Investments at the Bank of England.

January 27th, 1920.

JAMES C. MYLES }
J. WILSON } *Auditors.*

FREDK. J. PERKS, *Treasurer.*

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the 545th Ordinary Meeting of the Club, held on October 14th, 1919, Mr. D. J. Scourfield, F.Z.S., F.R.M.S., Vice-President, in the chair, the minutes of the meeting held on June 10th were read and confirmed.

Messrs. Frank A. Scott, F. E. Cocks and John Turnbull were balloted for and duly elected members of the Club. Eight nominations were read for the first time.

Mr. Scourfield said that as the last Ordinary Meeting had been held at 20, Hanover Square—and at that time the arrangements for moving to new premises were not completed—he would call upon the Secretary to explain the situation. Mr. Maxwell said that the main difficulty in finding new quarters for the Club was that of finding room for the Library and Cabinet. In spite of the fact that Mr. Perks had worked indefatigably for six months to find suitable quarters, it had not been found possible to obtain a convenient meeting-room together with the accommodation necessary for the books and slides. The secretary of the Medical Society of London had kindly promised to help the Club if they were in difficulties, and arrangements had been made to hold the meetings at the Society's house, 11, Chandos Street, Cavendish Square. It had been found possible to find room for the Cabinet, but not for the books. With regard to the Library, Dr. Rendle had very kindly approached the Trustees of the British Museum (Nat. Hist.), South Kensington, and obtained permission for the books to be housed in the Museum for the present. They are now in a private gallery at the Museum, and it is hoped that arrangements may soon be made whereby members may obtain access to them. The thanks of the Club were accorded to all those who had taken part in the work of finding new premises and moving the Club's property from 20, Hanover Square, special mention being made of Mr. Perks, on whom the main responsibility had fallen; the President, who had arranged for the disposal of the Library; and Commander Spry, of Plymouth, who had generously sacrificed two days of his holiday to superintend the removal of the library from 20, Hanover Square to the Museum.

The Secretary read a letter from Mr. Lawrence thanking those members who had taken part in the microscopical exhibition at Roehampton House, and asking if it would be possible to arrange another one. A letter was also received from Newbury Grammar School asking if one of the members could give a lecture there on the microscope or a microscopical subject.

Mr. Morley Jones exhibited a specimen of *Aulacodiscus grandis* (Walker and Chase), from Newcastle, Barbados, mounted to show the girdle view of the valve, and described the method he adopted for mounting heavy diatoms in such a position. A drop of thick gum tragacanth mucilage is dried on a slip, the diatom is placed upon it on edge, and the gum is breathed upon, so that the edge of the diatom sinks into it as it is moistened. The diatom will probably fall over unless it has a flat edge, and must be rearranged with the bristle while the gum is moist. When the attached edge is well embedded in the gum it must be breathed upon again, and the diatom supported with the bristle in the desired position until the gum dries. The diatom must then be examined with a high power (1/6 in.), and if not straight the operation must be repeated. The cover-glass should be supported on three pieces of cover-glass of suitable thickness. If the above method fails, the diatom may be gummed against the edge of a piece of cover-glass fixed on the slip, and the cover supported as before on pieces of cover-glass just thicker than the diameter of the diatom.

Dr. J. Rudd Leeson then gave an account of the Toothwort (*Lathrea squamaria*). It was, he said, one of those plants that one hears about all one's life and never sees. He had known of it for forty years, but never seen it until quite recently. The plant when fresh is white and fleshy, but it turns brown when preserved in spirit. It has received the name of toothwort from the tooth-like shape of its leaves, and its generic name, Lathrea, is derived from the Greek λάθρος, meaning "hidden," as the plant grows hidden among dead leaves and loose earth. It is allied to the broomrapes. The plant is perennial, and sometimes covers areas of a square yard; it is destitute of chlorophyll, and is a parasite on the roots of hazels, elms, beeches, etc. It lives in shady places, and its creeping rhizomes form a mat round the roots of the host, being attached to them by slender roots ending in a button-like expansion. In the spring a few flower stalks about 6 in. long are sent up; these are curved like a crook, and bear the pale rose-coloured flowers all on one side. The white, fleshy, much-branched rhizomes form the chief part of the plant, and the short thick leaves are arranged on them in four rows. The leaves are very remarkable; they appear to be doubled back on themselves, and so form a cavity with a small entrance, which is divided into from six to thirteen chambers. These chambers are lined with two sets of special cells, both of which are supposed to be able to send out pseudopodia and to assist in preventing the various small creatures that enter the cavities from escaping. These animals die and become absorbed probably by the watchglass-shaped cells to which vessels may sometimes be traced. The plant is thus a double parasite. It not only lives on the roots of trees, but it supplements its supply of nitrogenous food by catching, killing, and absorbing small insects and other creatures. Dr. Leeson then pointed out the various parts of the plant in a series of lantern-slides, and compared the insect-catching apparatus with that of the Alpine Bartsia and the butterwort.

The address was followed by an interesting discussion, in which many of the members took part. Mr. N. E. Brown said that the toothwort grew in Kew Gardens on the roots of rhododendrons and elsewhere. Mr. Paulson stated that a species of Lathrea grows in the Alexandra Park, at Hastings, also on rhododendrons. Toothwort is fairly abundant in the south-eastern counties, notably near Keston and Caterham. He himself had never found it north of the Thames. He had never seen the pseudopodia, and doubted whether anyone had. There was an excellent paper by G. Massee, in the *Journal of Botany*, twelve or fourteen years ago, in which he proved that the buttons on the roots are only formed just after the seed germinates, and then they disappear. He also showed that the plant obtained part of its nutriment as a saprophyte. Mr. Hilton objected to the use of the word "pseudopodia" in describing the protoplasmic threads which were supposed to be emitted by the special cells in the cavities. Another member said that toothwort required a moist alkaline soil, and was frequently found at the base of chalk hills. He had found it at the foot of the Chilterns. In his opinion, the insects went into the cavities by accident or for protection, and that they were not digested; he suggested that the knobbed cells were modified stomata. He asked why it was that parasitic plants turned black on drying. Mr. J. Wilson said that he had found toothwort as far north as Perthshire and Kirkcudbrightshire, and that, unlike other parasites, the Orobanches did not blacken on drying. Mr. N. E. Brown confirmed the fact that Orobanches did not blacken on drying, and stated that he had never seen the alleged "pseudopodia." In reply to a question by Mr. Inwards, he said that the toothwort did not appear to injure the host plant. Mr. D. Bryce thought it unlikely that the remains of rotifers had been found in the cavities, although they were supposed to have been found there.

At the 546th Ordinary Meeting of the Club, held on November 11th, 1919, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on October 14th were read and confirmed.

Messrs. David E. Williams, F. C. D. Jefferies, Harry C. Witt, Thompson Muskett, R. Freemason Cole, S. R. Wycherley, W. G. Parker, M.A., M.D., and Francis Dell were balloted for and duly elected members of the Club. Six nominations were read for the first time.

The Secretary announced that there would be a Gossip Meeting on November 25th, and that at the next Ordinary Meeting, on December 9th, Mr. D. J. Scourfield, F.Z.S., F.R.M.S., would give a short address on the use of the centrifuge in the collection of plankton forms. The Secretary also announced the gift to the Club of twelve slides (botanical sections) by Mr. Sidwell in memory of his friend and fellow-worker, T. R. Jarvis Edwards. The hearty thanks of the Club were accorded to Mr. Sidwell for his gift.

The President said that the Librarian had arranged the books of the Club Library in their cases at the Natural History Museum, South Kensington, and that in future he would be at the Museum from 2 to 4 p.m. on the first Saturday of each month for the purpose of giving out books or receiving books that had been borrowed. Members wishing to avail themselves of the Library should go to the Museum at the time stated. The books are in the "New

Herbarium" in the Botanical Section of the Museum on the top floor, and entrance may be obtained by ringing the bell at the door of the gallery.

The President announced the deaths of the Dean of Chester, who had been a member of the Club since 1878, and of Professor G. S. West, a recently elected honorary member. Professor West was known on account of his valuable contributions to the study of freshwater algae. Arrangements have been made for his monograph of the British Desmids, of which four volumes have been published by the Ray Society, to be finished by one of his students. Professor West has left his large collection of very beautiful drawings of freshwater algae to the Botanical Department of the Natural History Museum, South Kensington. The Hon. Secretary was directed to send a letter of condolence to Mrs. West on behalf of the Club.

Mr. Traviss exhibited a section of quartz showing a very large bubble in a cavity. He said that seven periods of rest had occurred during the growth of the crystal, and that minor crystals growing on one of the temporary surfaces could be seen by polarised light.

The President then called on Dr. G. H. Rodman to deliver his lecture on "Some Floral and Faunal Remains of the Coal Measures." The lecture was illustrated by a fine series of lantern slides. Dr. Rodman had been very successful in photographing some of the sections, which, on account of the variation in density of different parts of the object, were very difficult to photograph satisfactorily. The lecturer prefaced his address by drawing attention to the value of photography in recording the appearance of microscopic objects in cases where they are of no great thickness and the details recorded all lie in one plane. In cases where detail is required to be shown in several planes at the same time, and in other special cases, it is necessary and better to resort to the camera lucida. Dr. Rodman said the carboniferous beds were of very ancient origin, far older than the Oolite, Wealden and Cretaceous strata, though not so old as the Devonian and the Old Red Sandstone. The beds are classified into: (1) Upper carboniferous, consisting of the upper coal measures, in which are found fossil remains of fish and mollusca; (2) middle coal measures in which are found most of the fossil plant remains; (3) middle carboniferous; and (4) lower carboniferous, consisting of mountain limestone and limestone shale. The coal-bearing strata in South Wales have been estimated as being over 11,000 ft. thick, but only about 1/100th part consists of coal seams proper, the greater part of the thickness consisting of sandstone, clay and shale. The thickness of coal seams in this country usually varies between a few inches and 9 or 10 ft. Coal is formed from the vegetable debris of the leaves, fronds and spores of the primeval forests. In the first instance, a material was formed similar to that which we find in peat-bogs, and under the influence of heat, moisture and pressure from superimposed strata this peaty material became compressed into comparatively thin layers, so that a seam of coal only a few inches in thickness is formed from the accumulation of decayed material from forests of stupendous proportions. Eventually these beds became depressed so that marine or freshwater sediment was deposited over them, and then, again, the vegetation spread and flourished, and the same process was repeated perhaps many times. The seams of coal always rest upon a bed of clay known as the underclay, which represents the soil on which the coal-measure plants originally grew. In many cases the roots of trees are found upright in the under-clay, and can be traced upwards into the superimposed coal-bed, and found to be actually continuous with stems found in the upper layer or coal seam. Taking the Palaeozoic Lycopods or Giant Club-mosses of the coal measures, Dr. Rodman exhibited slides showing the structure of the stem and leaves. Many species of Lepidodendron and Sigillaria have been described from all parts of the world, showing a remarkable uniformity in the character of the vegetation. The trunks, though of slender proportions, were of considerable length. Photographs showing the characteristic leaf-scars in both genera were exhibited, taken from specimens in the British Museum. The root (Stigmaria) of Sigillaria was described and the relationship between stem and root demonstrated. Stigmariae are always found in the under-clay, and were at first described as separate fossil plants. The Calamites, so called from their fancied resemblance to reeds, were then described in detail, and the microscopic structure of their stems shown on the screen, demonstrating their very close relationship with recent Horse-tails—Equisetaceae. The very interesting group of plants—Cordaites—was dwelt upon by the lecturer, who pointed out that the group combined the characters of the modern Cycad type and Conifers. In appearance they must have resembled the Conifers of the southern hemisphere, such as the Kauri Pine. The interesting group of seed-bearing ferns—Pteridospermae—was illustrated by a beautiful series of slides from preparations of the fossil remains of *Lyginodendron Oldhamium.* Research during the last twenty-five years or so has shown that many of the fossil plants of the coal measures formerly accepted as ferns are now classed in this important group of the Pteridosperms. The naked seeds were borne on the ultimate divisions of the frond, which frond was very fern-like, and resembled either gigantic bracken-fronds or those of the Royal fern—Osmunda. This section of the lecture was brought to a close by the exhibition of a series representing the impressions of fossil plants from the coal measures, including ferns. Dr. Rodman emphasised the extreme importance of microscopic research in palaeobotany and said the most important results had been obtained of late years by this method.

The faunal remains are not nearly so extensive, consisting of mollusca, fishes, reptiles, and forms related to them. Photographs of *Prolecanites compressus,* goniatites and nautili, were shown, a section of *Goniatites listeri* showing a structure very much resembling that of the nautilus of recent times. Then followed slides of the jaw of a labyrinthodont, a section of a fossil bone showing the detail remarkably preserved, and imprints of fish scales, these latter showing very distinct evidence of the alternating layers of growth which are now recognised as recording the age of the fish or the number of times it has spawned. Among the finest slides were a series of photographs of sections of teeth of fossil fish, showing the structure very clearly.

In conclusion, Dr. Rodman showed a few slides of sections of recent plants for comparison with those of their fossil relations.

In moving a vote of thanks to Dr. Rodman, Dr. Rendle said that the plant remains found in the coal measures represented only a very small part of the vegetation of the period. We found remains of some plants growing by streams and in marshy places, but we knew nothing of the highland flora. It was doubtful, he said, if any of the so-called ferns of the coal measures were really ferns at all.

The meeting closed with a hearty vote of thanks to Dr. Rodman for his interesting lecture.

At the 547th Ordinary Meeting of the Club, held on December 9th, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on November 11th were read and confirmed.

Messrs. Arthur E. McClure, Leslie Price, F. W. Ellis, Harry Walkinson, Harry Wheeler, F.G.S., and John H. A. Verinder were balloted for and duly elected members of the Club. Five nominations were read for the first time.

The Secretary made the following announcement: The Committee have decided that *no meeting* shall be held *on December 23rd*, as it is so near Christmas. The next meeting of the Club will be held on January 13th, 1920. At this meeting Sir Nicolas Yermoloff, K.C.B., F.L.S., F.R.M.S., will read a paper entitled "Notes on Continuity and Discontinuity in Nature, as Illustrated by Diatom Structure," and Mr. C. D. Soar will read an abstract of a paper on "Water Mites of the Genus Eylais, written in conjunction with W. Williamson, F.R.S.E., F.L.S. The Committee hope that new members will avail themselves of the opportunities afforded by the Conversational Meetings to bring up their microscopes and seek advice or assistance in any difficulties connected with either their instruments or specimens. There are many members who are experts in various branches of natural history, and others who are skilled in microscopical manipulation and technique, and it is always a pleasure to any of these to be of assistance to those less-experienced members who are anxious to overcome the many difficulties that beset the beginner.

The Secretary read a note from Mr. E. M. Nelson on "Capped Eyepieces." Mr. Nelson gave detailed results of an investigation of the effect on the visible image of eyepiece-caps. He found that caps were a decided advantage. In addition to their keeping the eye-lens clean by preventing it from being touched, they improved the image. Mr. Nelson found that in most cases the size of the hole in the cap which gave the best results was smaller than that commonly used, but in no case was it anything like so small as the Ramsden disc. Stereoscopic effect with a binocular was also improved by reducing the size of the hole. Mr. N. E. Brown confirmed Mr. Nelson's results. Mr. Maxwell referred members to the *Journal* for information concerning the effect of a very small hole moved about in the plane of the Ramsden disc. Mr. Maurice Blood said that the only conceivable effect of Mr. Nelson's proposal would be to keep the eye central. A hearty vote of thanks was accorded to Mr. Nelson for his communication.

The President then called on Mr. D. J. Scourfield to deliver his address on "Nannoplankton and its Collection by means of the Centrifuge." Mr. Scourfield said that he had already brought the subject of collecting very minute pond-life organisms by means of the centrifuge before the Club in a paper read in 1911 (see *J.Q.M.C.* vol. xi. p. 243), but he thought the matter might possibly be worth bringing up again especially in view of the fact that the more minute organisms that float in fresh water had not even yet received their due attention in this country. The word "plankton" was introduced by Hensen in 1887 to describe the small, mostly microscopic, organisms possessing but feeble powers of locomotion, that float in the ocean, lakes, ponds, etc. Not much attention was paid at first to the smallest of these forms, *i.e.* to those which passed freely through bolting silk of 200 threads to the inch, whose openings are about 1/400th to 1/500th of an inch across. Lohmann observed, however, that the Appendicularia possessed an apparatus which collected great numbers of extremely small organisms, which were accumulated in a sac before being swallowed, and in 1908 he suggested that the centrifuge be used for the concentration of such very small forms. A little later he introduced the term "nannoplankton," *i.e.* "dwarf plankton," for those organisms which pass readily through the meshes of the finest silk nets and whose upper limit of size is about, say, 11,000th in. Mr. Scourfield then described the method followed. A two-speed hand centrifuge is used, which will give with the lower gear 2,000 to 3,000 revolutions per minute with 15-c.c. tubes. If the higher gear is used with tubes of 1½-c.c. capacity, a speed of 10,000 revolutions per minute may be obtained. Even with this speed some very minute forms (*e.g.* bacteria) may not be thrown down. Unconcentrated material is used, collected in a bottle and centrifugated for two to three minutes. The water is then nearly all gently pipetted off and the sediment examined either in a Rousselet live-box or on a slip with a cover. Mr. Scourfield prefers Rousselet live-boxes with a thin metal ring in the cover, to which a cover-glass 1/300th in. thick is cemented. Nannoplankton comprises phytoflagellates, peridinieae, bacteria, small volvocaceae, diatoms, desmids and, in the sea, silicoflagellates. Of animal forms there are zooflagellates and a few of the smallest ciliates, rhizopods and heliozoa. The late Prof. West said that very little was known about the smaller British flagellates and it is often difficult to differentiate between animal and vegetable forms, but probably most of them should be included in the Algae.

Many of the pond-dwellers, such as Daphnia, Rotifers, etc., are probably dependent on the nannoplankton for food—for this reason it is undesirable to add tap-water to pond-life material that is required to be kept. In a lake in Austria containing abundant nannoplankton a certain species of Daphnia flourished; but in an adjacent lake, where larger plankton forms were abundant but nannoplankton organisms were not, the same species of Daphnia did not thrive. The reproduction of the minute plankton forms is very rapid, and it is probable that they play a very important rôle, especially in the Tropics. A series of slides was then thrown on the screen, showing the comparative sizes of the meshes in bolting silk of different degrees of fineness, and a number of drawings of some of the minute but very beautiful forms obtained by means of the centrifuge. The President, in thanking Mr. Scourfield for his very interesting and instructive address, regretted that rather special apparatus appeared to be necessary, and asked how far it was possible for a beginner to do such work, and what was the minimum apparatus necessary. Mr. Paulson asked how long the concentrated material could be kept, and of what the food of the nannoplankton consisted. Mr. Hilton asked if any estimate had been formed of the number of minute organisms in a given volume of unconcentrated water. Mr. Scourfield said that it was necessary to use a 1/10-in. water-imm. or a 1/12-in. oil-imm. objective of about N.A. 1·25, and a fairly good condenser. A thin film of water seemed desirable in observing the organisms. Some of the organisms would keep, when concentrated, for a few days, but as a rule they did not last very well. Important work could be done in finding some means of permanent preservation. As regards their food, the organisms were considered to be mostly vegetable, and to obtain their food as plants do. Counts had been made of the number present in various places under natural conditions, but Mr. Scourfield could not trust himself to give the figures from memory. Mr. Akehurst said that he had adapted an inexpensive mechanical toy as a centrifuge. A very hearty vote of thanks was accorded to Mr. Scourfield for his address.

At the 548th Ordinary Meeting of the Club, held on January 13th, 1920, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on December 9th, 1919, were read and confirmed.

Messrs. Leonard S. Dimsdale, Norman L. Gillespie, Cyril M. Withycombe, Eric D. Mahony and Eric Fitch Daglish, Ph.D., were balloted for and duly elected members of the Club. Six nominations were read for the first time.

The Secretary announced that the Annual General Meeting would be held on February 10th, when the officers and committee for the coming year would be elected, and Dr. Rendle would deliver his presidential address. The President read the list of those nominated by the committee, and four gentlemen were nominated by the meeting to fill the vacancies caused by the retirement of the four senior members of the committee. The President announced that Mr. Wilson had been chosen to represent the committee as auditor, and the meeting elected Mr. Miles to act with him on behalf of the members. The announcement that Dr. Rendle had consented to occupy the presidential chair for another year was received with acclamation.

The President then called upon Sir Nicolas Yermoloff, K.C.B., to read his paper, "Notes on Continuity and Discontinuity in Nature as illustrated by Diatom Variation." Sir Nicolas said that in the paper which he read before the Club in 1918 he had endeavoured to trace the evolutionary relationships in a group of Naviculoid diatoms so closely connected by intermediate forms that it was hardly possible to tell where one form ended and the next began. The line of variation of these forms might be described as a line of variation in time. In the present paper he proposed to make a comparative examination of several other groups of diatoms—viz. of Discoid and Gonoid diatoms, trying to trace their morphological relationship with forms from several fossil deposits—viz. those of Mors, Simbirsk, and Oamaru (to these ought to be added that of Barbados, but this was left out for brevity's sake). This variation could be called variation in space. Sir Nicolas had prepared a printed comparative list showing forms of the Discoid and Gonoid groups common and peculiar to the three deposits. These deposits belong to widely separated localities, they are all strictly Pelagic, and they are in some ways very similar. It has been suggested that they belong to the

Oligocene period, when Europe suffered great oceanic invasions, one from the Arctic seas towards Denmark, and another from southern waters northwards towards the latitude Riga-Simbirsk. At the same time the seas covering Southern Russia had communication round the Urals with Arctic seas, so that we should expect to find Arctic forms in the Mors deposits, both Arctic forms and forms from the warmer southern seas in the Simbirsk deposits and sub-tropical ones in the Barbados and Oamaru earths. And so it seems to be. This hypothesis also seems to indicate that diatoms are not of very early origin, which suggestion seems to be confirmed by the fact that none have so far been found in the coal measures. Diatom systematics are usually supposed to be overcrowded and confused by the creation of many species and varieties based often on very small differences. The cause of this confusion lies not with the classifier, but with the diatoms. Their skeletons are indestructible, so that not only species and varieties, but intermediate forms are preserved, and as Evolutionists we should be very grateful for this. It gives us an opportunity of studying continuity and discontinuity in nature. Sir Nicolas then proceeded to define the two terms with examples. Variation is said to be continuous when the differences between two states of the variable are infinitely small, and discontinuous when these differences are not infinitely small, but finite, small or large. A photograph was then shown on the screen of 119 forms of the genus Coscinodiscus. The genus contains about 300 species, and an infinite number of intermediate forms very difficult to classify. Some of the forms very nearly approach continuity, while others represent real or it may be only quasi-discontinuity—real if intermediate forms do not exist, quasi if for some reason, as on the slide shown, they do not appear. The changes of absolute continuity are capable of neither numeration, measurement nor observation, and so we observe that many changes in nature appear as a so-called "jump." After further remarks and examples of discontinuity in nature, Sir Nicolas returned to the deposits. They show several interesting features in common: (1) Each has a dominating form or group of forms—in Simbirsk, *Coscinodiscus symbolophorus*, *Actinoptychus heterostrophus* and the *Triceratium-Hemiaulus* group; in Mors, the *Trinacria-Hemiaulus* group; in Oamaru, *Stephanopyxis Grunowii* and the *Triceratium-Trinacria* group, the latter dominating in species and varieties though not in numbers. (2) All three deposits repeat genera, but not as a rule species. This tends to confirm the idea that the deposits are not of the oldest origin, evolution having had time to alter species, to adapt them to local environments, but no time to influence the genera. (3) On the other hand, some species and even genera are peculiar to one or two of the deposits and show no variation. Thus Simbirsk and Mors both contain *Odontotropis carinata* and *O. hyalina*, neither of which have been found anywhere else except in Franz Joseph Land. Simbirsk has several peculiar genera, such as *Lepidodiscus*, *Pyrgodiscus*, and *Cheloniodiscus*. *Janischia antiqua* is peculiar to Mors. Oamaru is the richest in species, but has no particular genus. (4) Some genera, such as *Triceratium*, *Hemiaulus*, and *Coscinodiscus*, have left more intermediate forms, and are consequently very difficult to classify. (5) The genera *Chaetoceros* and *Rhizosolenia* are absent from all three. This may be because these diatoms thrive in shallow coastal waters and the deposits are strictly pelagic. Sir Nicolas then stated a few conclusions : (1) Mors is the poorest in species and Oamaru the richest—suggesting that warm waters are conducive to variation. (2) Individual and varietal variation approach the continuous method, while specific and generic variations tend towards quasi-discontinuity. (3) The evolutionary ladder appears to be continuous, but "mutations," or non-continuous variations, as exemplified by cases of "sports" among plants and animals, exist.

The Barbados deposits show affinities with those of Oamaru, especially in the presence in both of genera such as *Brightwellia*, *Craspedodiscus* and *Porodiscus*, in which the centres of the discs have structures differing from that of the rest of their surfaces.

Dr. A. Smith Woodward spoke of the value of diatoms in the correlation of rocks, and after some remarks by Messrs. A. E. Hilton and N. E. Brown. a hearty vote of thanks was accorded to Sir Nicolas Yermoloff, on the motion of the President, for his valuable paper.

The President then called upon Mr. C. D. Soar to give an abstract of his paper on "Water Mites of the Genus Eylais." Mr. Soar said that the genus was established by Müller in 1776, and for 100 years it remained represented solely by *Eylais extendens*. The genus is notable in that the hind pair of legs is not used for swimming. Eventually it was discovered that what was considered to be only one species consisted of a number of species characterised by minute differences, one of these being the differences in the shape of the eye plates. Mr. Soar showed on the screen figures of the mites, also some drawings by Schrank and Koch, and a slide showing figures of the eye plates of all the species of the genus found in the British area.

A hearty vote of thanks was accorded to Mr. Soar for the interesting *résumé* of his paper.

At the 549th Ordinary Meeting, being also the fifty-fourth Annual General Meeting of the Club, held on February 10th, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on January 13th were read and confirmed.

Messrs. W. Murray Scott, Granville M. Grace, C. Willoughby Poignard, Gordon Fryer, Henry Goullee and Lionel S. Day were balloted for and duly elected members of the Club. Ten nominations were read for the first time.

Mr. A. D. Michael, a past president of the Club, was elected an honorary member.

The President brought for distribution some of the diatomaceous deposit from Lompoc, Sta Barbara, Cal., which had been kindly sent by Dr. A. Smith Woodward, who had referred to it at the previous meeting of the Club. Mr. Akehurst exhibited an inexpensive centrifuge, which he had made some years ago from part of the mechanism of a toy and a centrifuge head. Mr. Morley Jones showed a strewn slide of the Lompoc material, and stated that the material was unusually easy to clean.

The Secretary announced that, after carefully considering the matter, the committee had decided that for the present, owing to the very great increase in the cost of printing, only one number of the *Journal* would be issued during the year instead of two. The President then read the list of officers and committee for the ensuing year. Only a sufficient number of nominations having been made to fill the vacancies, no ballot was necessary. The President then called upon the Hon. Secretary to read the Annual Report. The Hon. Secretary said that the Report was, on the whole, satisfactory. During the year thirty-seven new members had been elected, three had resigned, and ten had died, leaving a total membership of 464 on December 31st. The chief event of the year had been the removal of the Club from 20, Hanover Square, to its present premises, and it was a matter of some regret that, although the Library was available from 2 to 4 on the first Saturday of each month at the National History Museum, South Kensington, the activities of the Club were somewhat curtailed by the impossibility of housing the Library at the place of meeting, and by the difficulty at present of using the Club Cabinet. The slides were undergoing a careful revision by the Curator, and the collection was now fairly representative, although there were many gaps which could only be filled by the generosity of members. The report of the Hon. Sec. of the excursions sub-committee was very satisfactory, the average attendance being 21·9, the second highest since the foundation of the Club. The Treasurer regretted that he had to present the worst balance-sheet during his term of office. The chief item of expense was the *Journal.* The President said that the Club had passed through a very trying year, but that it might have been worse off. It was a matter for regret that the Library was separated from the meeting-room, and that the slides were not yet available. The balance sheet was a matter of great concern to the committee, who were anxious to find some means of reducing expenditure without reducing the efficiency of the Club. The President then asked Mr. D. J. Scourfield to take the chair, and delivered his Annual Adress.

Dr. Rendle took as his subject the Seed-leaves or Cotyledons, making special reference to the seed-leaves of grasses. He said that the importance of these structures in the system of classification was recognised by John Ray, whose *Historia Plantarum* (1686–1704) may be regarded as the beginning of the natural system of classification. Ray retained the old division of plants into Herbs and Trees. The former were subdivided into Imperfectae (flowerless) and Perfectae (flowering), and the Perfectae and the second main group, Arbores, were each divided into Dicotyledones (with two cotyledons) and Monocotyledones (with one or no cotyledon). This division of seed-bearing plants into groups with one or two cotyledons played a more or less important part in subsequent attempts to portray a natural system of classification. Dr. Rendle proposed to examine the bearing of the structure and development of the seed-plant embryo on the concept of the seed-leaves. The leaf-character of the paired seed-leaves of the dicotyledon is obvious where they push above the ground and spread horizontally to form the first pair of green leaves, between which is protected the bud of the main stem; and in the pea, acorn, etc., where the seed-leaves are enlarged to act as a store of nourishment and are never raised above the soil, the resemblance to a pair of leaves protecting the main bud is still obvious. The function of the cotyledons is nutritive and protective. During germination they absorb the food material by which the embryo is generally more or less surrounded for the benefit of the seedling and protect the plumule or stem-bud while it emerges from the seed-coat. In monocotyledons the leaf-character of the cotyledon is less generally obvious. In the simplest case the tip remains in the seed till the endosperm is absorbed, then it becomes free, straightens out, and forms the first green leaf, and the first true leaves break through its sheathing base in succession. More often the tip of the cotyledon forms a sucker, which remains in the seed and is connected with the sheath (through which the first leaf of the stem-bud grows) by a longer or shorter portion. From this we pass to the highly specialised grass-type. Here the sucker (scutellum) is a very definite organ, while the germ-sheath protecting the stem-bud (pileole) forms the first green blade. In many grasses there is a small scale-like appendage opposite the scutellum, the epiblast. The scutellum, epiblast and germ-sheath have been variously interpreted, in seeking an explanation of the grass cotyledon, as representing a single leaf or two or three leaves. Comparison with the other monocotyledonous seedlings suggests that the scutellum is the sucker and the germ-sheath the sheath of one and the same cotyledon. On this view the epiblast and the apparent internode (mesocotyl), which sometimes occurs between the scutellum and germ-sheath, require explanation. There are various other interpretations. Mirbel regarded the scutellum as the cotyledon, the epiblast as a rudimentary second cotyledon, and the germ-sheath as the first green leaf. Richard explained the scutellum and epiblast as being a distinct absorptive organ, and the sheath as the cotyledon, and Schleiden called the scutellum the cotyledon, the epiblast part of its sheath, and the sheath the first leaf. Dr. Rendle then proceeded to show that if the development and anatomy of the grass embryo be studied, the view derived from our comparative study is supported.

An examination of the early development of the embryo raises other questions. In most monocotyledonous embryos the cotyledon is terminal, and the stem apex is a subsequent lateral development of the axis (hypocotyl) beneath it. On the view that a leaf is by definition a lateral outgrowth from the stem, the stem apex has been supposed to have been pushed aside by the really lateral cotyledon, but this is a purely theoretical assumption. In a species of rush several leaves in succession follow the cotyledon, each arising from the sheath of the preceding before the stem apex develops. In the early stages of dicotyledons we find a terminal symmetrically bifid structure between which the stem apex is subsequently developed. Here, again, the strict leaf definition fails, and the view has been taken that the cotyledons are not lateral, but represent a single bifid terminal one. This, however, involves the difficulty of supposing the stem to arise from the centre of the single cotyledon. Prof. Bailey Balfour has suggested that the embryo should not be regarded as a replica of the adult plant, but merely a protocorm of embryonic tissue adapted to a seed life which may develop organs not represented in the adult plant. In conclusion, a number of drawings of developing seedlings were shown on the screen and explained by the President. A hearty vote of thanks was accorded to the President for his interesting address.

At the 550th Ordinary Meeting of the Club, held on March 9th, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on February 10th were read and confirmed.

Mrs. Louise de Moule, Miss Lillian Lees, the Rev. Canon G. R. Bullock-Webster, Rev. Ernest Wightman, Messrs. E. H. Grant, Herbert W. R. Room, Chas. H. Oakden, Percy H. Trotman, R. H. Marchmant and H. A. Harries were balloted for and duly elected members of the Club. Six nominations were read for the first time.

The Secretary announced that the fixture cards for the new session would be printed and sent to the members as soon as the arrangements were completed for the excursions. The first excursion would be to the Royal Botanical Gardens, Regent's Park, on Saturday, April 10th; members to meet at 2.30 at the south entrance. There would be a Conversational Meeting on March 23rd, at 7 o'clock, and the next Ordinary Meeting would be held on April 13th at 7.30 p.m., when Mr. C. H. Caffyn would give an address on " The Microscopic Structure of Rocks."

The President then called on Mr. A. E. Hilton to read his paper on " A Log and Some Mycetozoa."

Sir Nicolas Yermoloff said that the Mycetozoa were a startling example of discontinuous variation. The spore when in suitable surroundings gives rise to a flagellate form, which passing through the plasmodium stage reaches a more or less fungoid condition. Energies in nature are continuous, but their manifestations are not always so.

In answer to questions from various members, Mr. Hilton said that he did not think light was a factor in the movements of plasmodia, but they might avoid a very strong light. He thought plasmodia would be likely to penetrate the wood rather than remain on the surface, because the conditions were more favourable below the surface. He did not believe the plasmodium of Lamproderma ever assumed an amoeboid form. The spores were sown where the log was most damp and rotten.

The meeting closed with a hearty vote of thanks to Mr. Hilton for his interesting paper.

At the 551st Ordinary Meeting of the Club, held on April 13th, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on March 9th were read and confirmed.

Dr. Vida A. Latham, Mrs. Violet Spender, Capt. Bertram S. Curwen, Messrs. Oswald A. Grosvenor, Edgar J. Summers and Ernest A. Miquot were balloted for and duly elected members of the Club. Two nominations were read for the first time.

The Secretary announced that Mr. Rheinberg had presented a copy of his paper (*Trans. of the Optical Society*) on Graticules to the Club.

A letter from the secretary of the Essex Field Club was read enclosing a copy of a resolution that the Club had passed, and asking if the Quekett Microscopical Club would take action on similar lines. The resolution was as follows :

" That this society views with alarm and indignation the proposal to introduce a private Bill into Parliament with a view to enclosing parts of Epping Forest and Wanstead flats as permanent allotments, and so nullifying the Epping Forest Act of 1878, which provides that the forest shall be preserved unenclosed for the enjoyment of the public for ever."

Mr. J. Wilson moved and Mr. D. Bryce seconded a similar resolution, and it was passed unanimously, the Hon. Secretary being directed to send copies to the proper quarters.

The Secretary announced that the next excursion would be to Chingford and Loughton, and would take place on April 24th, the members to leave Liverpool Street by the first train after 2 o'clock. There would be a Gossip Meeting on April 27th, and at the next Ordinary Meeting on May 11th Mr. Wycherley would read a paper on "The Microscopical Examination of Paper Fibres."

The President then called on Mr. Akehurst to describe the Silverman illumination which he was exhibiting at the meeting. The lamp consists of a glass tube 1/4 in. in diameter, which either encircles the objective and is held in place by three metal fingers that grip it, or else is supported below the objective by an attachment to the stage when the working distance of the objective is very considerable and the lamp would otherwise be too far from the object to be illuminated. A tungsten filament extends nearly the whole length of the tube. The back of the tube is silvered. The voltage is 14, and may be raised to 18 for photographic purposes. Mr. Akehurst said that he had been able to obtain enough light to show a dry-mounted *Pleurosigma angulatum* with an oil-immersion objective. As the incandescent filament does not quite form a complete circle, the light is slightly oblique, but a shutter is provided by which greater obliquity may be obtained if required. Mr. Akehurst then showed a few photographs taken with the illuminator, including one of the surface of cast iron, and, for comparison, another photograph taken with an ordinary vertical illuminator. The results obtained with the new lamp were very satisfactory. It was found that the temperature of an objective to which the lamp was attached was raised to 50° or 60° C. in twenty minutes, and it then remained stationary.

Mr. Jas. Burton sent for distribution a quantity of the pretty little water fern *Azolla*, taken from a pond at Bournemouth. The plant is sub-tropical, and, although not at all common in this country, it is fairly frequently found. Mr. Wilson had found it fifteen years ago in Hainault Forest, and two years ago it was common in the backwaters of the Thames near Richmond, and at Sunbury and Hampton. The President said that there were several species of *Azolla*, and that the plants sometimes lived through a mild winter in this country. Its chief interest was on account of the alga *Anabaena azollae* living in the chambered leaves. The plant comes from South America.

The Hon. Secretary then read two notes from Mr. E. M. Nelson. In the first Mr. Nelson pointed out inaccuracies in the figure and description of *Conochilus volvox* in the Micrographic Dictionary. The points referred to were explained by means of figures on the blackboard. In the second Mr. Nelson gave an interesting account of "The Birth of a Flagellate." He was watching a small cluster of four green pear-shaped bodies, enclosed in a gelatinous envelope. It was 13μ in diameter, and had anchored itself to the cover by one of its flagellae, each of the green pear-shaped bodies having one. While watching it one flagellum got stouter than the other, which gradually disappeared. Then the pear-shaped bodies became paler, and eventually vanished. Bright granules grew in the gelatinous parts, and finally the organism became a pear-shaped flagellate with a proboscis-like flagellum. The time taken was two hours. Votes of thanks were accorded to Messrs. Akehurst, Burton and Nelson for their communications.

The President then called upon Mr. C. H. Caffyn to deliver his lecture on "Rocks and their Microscopic Structure." Mr. Caffyn started by showing on the screen a photograph of his machine for cutting rock sections, and gave a brief description of the method adopted, illustrating his remarks by means of a series of preparations showing different stages in the making of a section from the rough hand specimen to the finished slide. Nicol, the inventor of the polarising prism that bears his name, was apparently the first to cut thin sections of minerals and silicified fossil wood about 1828. The method described is practically the same as that used now, except that chips were used instead of slices. The first real use of thin sections of rock for petrological examination was made by H. C. Sorby in 1850, when he ground sections of calcareous grit, and described the microscopical structure of sandstone. Very little work on this line was done in England except by Sorby, although it was taken up in Germany by Oschatz, and real microscopical petrology can safely be said to start with the publication of Zirkel's book on Rocks in 1863.

Rocks are divided into three main groups—igneous, sedimentary, and metamorphic. The igneous rocks are found in the greatest variety, and show the most interesting structures. Igneous rocks were originally molten in the interior of the earth, and as they cooled the various minerals crystallised out, generally those with least silica crystallising first, and the others following, according to the increase of silica. Gradual cooling, generally at a great depth, produced coarse-grained rock ("plutonic"). If the magma were injected into cracks in already consolidated rocks, it cooled more quickly, and a finer-grained rock was the result. These rocks are called "intrusive." If the mass were poured out at the surface ("extrusive" or "volcanic" rocks), it cooled very quickly, and sometimes solidified as glass without any crystals at all. From this it is seen that a molten magma having a definite chemical composition may crystallise in three distinct forms, according to its environment. For instance, if it solidified at great depths under heavy pressure, it would form a coarse-grained granite; intruded into fissures near the surface it might be a quartz-porphyry, or pitchstone; while if it were poured out at the surface from a volcano, it would be a rhyolite. The nomenclature of rocks is based partly on the mineral content and partly on the chemical composition. Igneous rocks are divided into four groups, according to the silica content. *Acid* rocks contain over 66 per cent. of silica, *Intermediate* between 66 per cent. and 52 per cent., *Basic* less than 52 per cent. and *Ultrabasic* less than 40 per cent. It is difficult to settle the names of the various types, as they merge one into the other, so that the present names do not represent definite chemical or mineralogical compounds. Mr. Caffyn then showed on the screen a series of photographs illustrating the main types into which rocks are divided. Most of the photographs were taken on Lumière Autochrome plates by Mr. Caffyn and Mr. Ogilvy, and were most faithful representations of the actual colours seen under the microscope. The magnification in most cases was × 20 on the slide. The members much appreciated the beautiful lantern slides, and a hearty vote of thanks was accorded to Mr. Caffyn for his interesting lecture.

At the 552nd Ordinary Meeting of the Club, held on May 11th, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on April 13th were read and confirmed.

Messrs. Patrick Ryan and Maxwell K. Stone were balloted for and duly elected members of the Club. Five nominations were read for the first time.

The Secretary announced that there would be a Gossip Meeting on May 25th, and that the next Ordinary Meeting would be held on June 8th, when Mr. R. Paulson would read a paper on "The Microscopic Structure of Lichens." The next excursion would be on May 29th to Greenford and Hanwell. The President announced that a copy of the third edition of Dr. Spitta's book, *Microscopy*, had been received from the publisher, Mr. John Murray. The Secretary said that he had many sympathetic replies from the various people to whom copies of the resolution protesting against the proposal to enclose part of Epping Forest had been sent. If the scheme is persisted with, the County Council will oppose it, and there will be so much opposition that it is very unlikely that anything will come of the attempt.

The President then called upon Mr. S. R. Wycherley to read his paper on "The Microscopic Examination of Paper Fibres."

Mr. Wycherley began by briefly describing the process of paper-making. Paper consists almost entirely of vegetable fibres pulped and shaken together so as to form a network, and the length and strength of the fibres, combined with variety of sizing and finish, give the distinctive features to the paper produced. The first process is the removal of all parts of the plant that are not cellulose, and for this reason rags are largely used as the basis of paper-making, as this has already been done. In making rag-paper the rags are first sorted into colours and qualities. They then pass through the rag-cutter and the duster, where they are cut into smaller pieces. They may then be washed and boiled in caustic soda. The material is then well washed, and still further broken up in the breaker or hollander. It is now bleached with chloride of lime, the coloured rag pulp requiring more bleaching, and the fibre being weakened in consequence. The material is then passed into the beaters, where it is still further separated. The sharpness of the knives in these machines affects the character of the paper considerably, blunt knives giving long fibres, used for strong paper, and sharp knives short-cut fibres, suitable for blotting and other soft papers. Here, also, the body and surface are modified by loading with China clay, calcium sulphate, barium sulphate, or starch, and dyes are also added. In the making of absorbent papers the pulp is now run on to the paper-making machine, but in the case of writing papers sizing is necessary. This may be done by adding resin and alum to the pulp in the beaters, giving engine-sized paper, or the paper when made may be passed through a vat of size. After leaving the beaters the pulp is strained, and then passed into the paper-making machine, which consists of a travelling wire web that oscillates horizontally, so shaking the fibres in two directions. During this process some of the water is removed by suction, and the paper is dried by being passed over the couch rollers, and finally over the drying cylinders with the dry felts. Whatever material is used in making paper the principle is the same.

When a microscopical examination is to be made of a sample of paper it is disintegrated by boiling in weak caustic potash solution, washed and teased out with needles in a watchglass of water. A small quantity of this fibrous matter is put on a slip in a drop of water and covered with a cover-glass; it is then examined to identify the fibres and roughly to estimate their percentage. The fibres present in paper are: Linen and cotton in high-class papers, wood fibres from wood pulp, either mechanical or chemical, esparto grass, straw, jute, hemp, wool, and, in papers made in the East, bamboo, silk and many other materials. Mr. Wycherley then described the appearance under the microscope of the various fibres.

Linen.—Long, rounded, or irregularly hexagonal fibres. Natural ends pointed, but probably frayed during treatment. This is known as lamination, and if excessive indicates undue breaking of the fibres, probably in the beaters, leading to weakness of the paper, although the material may be of the best quality. A canal runs regularly from end to end. The bending of the fibres during manufacture causes creasing. The nodes, which are like bamboo nodes, are usually burst, forming slight hooks, which bind the fibres together and strengthen the paper.

Cotton.—Distinguished from similar fibres in wood pulp by the use of the polariscope, when the bordered pits of the latter are clearly shown up. Fresh fibres are round, but they become flattened and invariably twisted. A canal and longitudinal striation can be traced. Nodes such as are present in linen fibres are absent.

Wood Fibres result from mechanical or chemical wood pulp.

The former are the fibres of wood crushed and broken into pulp. It is used only for the commonest papers; fibres are short, broken and coarse, parts of the medullary rays are frequently seen. Chemical wood pulp is made by boiling the wood under pressure in caustic soda, calcium bisulphite, or sodium sulphate. Strong brown papers are made by the last method in the Scandinavian mills, the length of the fibre being retained by slow cooking and careful disintegration. The fibres are larger, cleaner and less broken than in mechanical wood pulp.

Esparto Grass.—Brittle and soft papers, known as grass papers, are made from this. The fibres are short, smooth and round, with a central canal and pointed ends. Cellular hairs from the leaf surface are always present, as, although useless, they cannot be filtered out; they serve, however, the purpose of diagnosing the presence of esparto.

Straw Fibres, used only in coarse wrapping-papers, are shorter and thicker than esparto and more brittle. They show bands and creasing and characteristic cellular hairs.

Jute Fibres have an irregular canal, nodes and parallel longitudinal striae.

Manilla Fibre, from hemp, is a long fibre, and one of the strongest used in paper-making. The walls are thin and the canal wide; no nodes are observable. It is used for making strong paper when a good colour is not essential.

In addition to the above vegetable fibres, animal fibres are often found. Silk fibre is long and smooth, and does not hold together well. Wool fibres are often used in filter-papers and other similar soft-sized paper. They are easily recognised by their markings. Sketches of the various fibres were made on the blackboard. In examining fibres 1/4-in. or 1/6-in. objectives are used, and frequently polarised light. For permanent mounts glycerine jelly is suitable. The materials used in loading the paper may often be recognised. China clay as small oval particles, calcium sulphate as irregular crystals, mostly prisms and needles, barium sulphate as diamond and wedge-shaped crystals, and starch granules may be easily recognised.

In answer to the many questions that were asked by the members after the paper had been read, Mr. Wycherley said that the refuse from sugar canes was used in Indian and Chinese paper mills like bamboo. Thin, tough papers, such as India paper, cigarette paper, and also the Japanese hand-made papers, are probably made from high-grade cotton. When old paper is used for making new paper it is necessary to add fresh material in order to stiffen it. Mechanical wood-pulp paper goes brown, and falls to pieces very quickly. Wood-pulp and cotton-fibre paper lasts well, but for real lasting qualities that made of linen and cotton fibre is the best. Jute would last, but the colour is bad. The best paper is made from white rags, as less bleaching is necessary. The melting together of the fibres in grease-proof papers is done by chemical means; prolonged heating would not have the same effect.

A very hearty vote of thanks was accorded to Mr. Wycherley for his interesting paper.

At the 553rd Ordinary Meeting of the Club, held on June 8th, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on May 11th were read and confirmed.

Miss Blanche Dell, Messrs. Lionel B. Ridley, C. E. Raison, A. W. Richardson and Alfred W. Stokes were balloted for and duly elected members of the Club. Five nominations were read for the first time.

The Assistant Hon. Secretary announced that the next Ordinary Meeting would be held on September 14th, Conversational Meetings being held as usual on the second and fourth Tuesdays of each month until that date.

A valuable paper by Mr. G. T. Harris on "The Desmid Flora of a Triassic District" was taken as read. The Assistant Hon. Secretary read the following paragraph from the paper, which gives some idea of its scope:

"The comparative table given of the desmid floras of the two districts (Dartmoor and East Devon), one a Palaeozoic semi-mountainous area of extensive peat deposits, excessive rainfall and deep bogs, the other a Triassic lowland area with no peat deposits, moderate rainfall and bogs unimportant both in depth and extent, would indicate that the factors influencing the richness or poverty of desmid floras must be sought for elsewhere than in the geological beds upon which the habitats stand, and a recent investigation of the desmid flora of a district on Eocene beds confirms this statement."

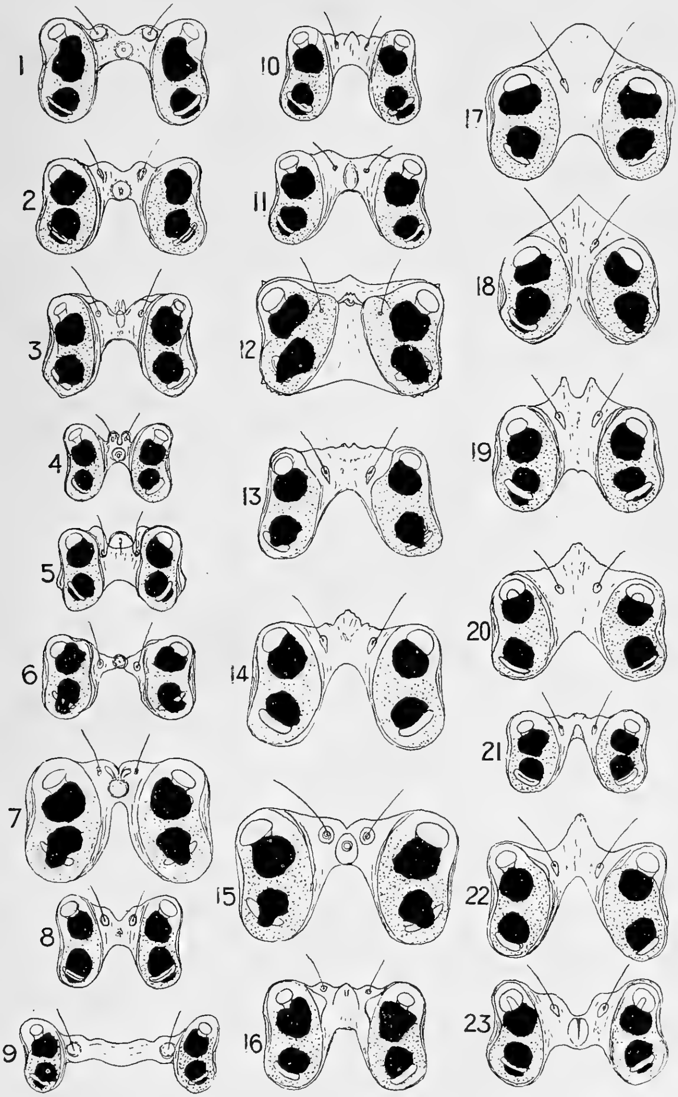
A hearty vote of thanks to Mr. Harris was carried by acclamation. The President then called on Mr. R. Paulson to read his paper on "The Microscopical Structure of Lichens."

Mr. Paulson in his remarks on the subject-matter of his paper laid great stress on the importance of careful and accurate microscopical manipulation in the research into lichen histology. He pointed out the necessity, very often overlooked, of paying great attention to the illumination in critical work of this kind. Much attention had been paid in the past years to the description and classification of lichens, and as this part of the subject is approaching finality it leaves the field open for the histologist. In his paper he gave the results of his own researches and indicated further lines along which fruitful work might be done. It was Mr. Paulson's intention to show a series of photomicrographs made from his preparations, for which he is indebted to the courtesy and help of Mr. J. H. Pledge, and then demonstrate some of the conclusions he had arrived at. Unfortunately the lantern failed to act after the general photographs of lichens had been shown. Mr. Paulson kindly promised to show the lantern slides at the next Gossip Meeting on June 22nd.

TABLE FOR THE CONVERSION OF ENGLISH AND METRICAL LINEAR MEASURES; YARD AT 62° F. AND METRE AT 0° C.

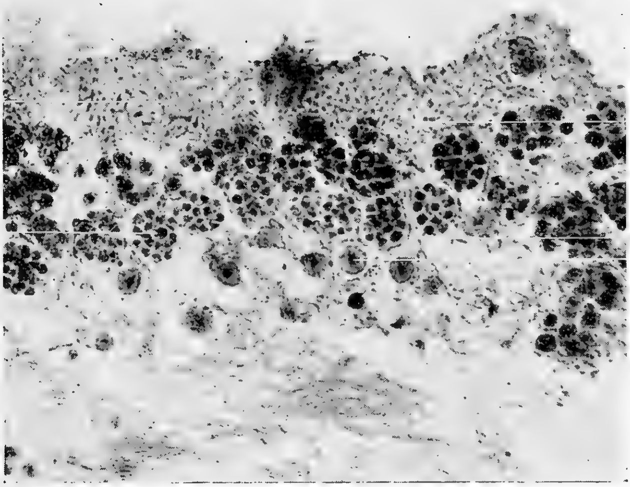
1 ÷	mm.	1 ÷	μ	1 ÷	μ	1 ÷	μ	1 ÷	μ
2	12·70	27	941	53	479	79	322	125	203
3	8·47	28	907	54	470	80	317	130	195
4	6·35	29	876	55	462	81	314	135	188
5	5·08	30	847	56	454	82	310	140	181
6	4·23	31	819	57	446	83	306	145	175
7	3·63	32	794	58	438	84	302	150	169
8	3·17	33	770	59	431	85	299	155	164
9	2·82	34	747	60	423	86	295	160	159
10	2·54	35	726	61	416	87	292	165	154
11	2·31	36	706	62	410	88	289	170	149
12	2·12	37	686	63	403	89	285	175	145
13	1·95	38	668	64	397	90	282	180	141
14	1·81	39	651	65	391	91	279	185	137
15	1·69	40	635	66	385	92	276	190	134
16	1·59	41	620	67	379	93	273	195	130
17	1·49	42	605	68	374	94	270	200	127
18	1·41	43	591	69	368	95	267	205	124
19	1·34	44	577	70	363	96	265	210	121
20	1·27	45	564	71	358	97	262	215	118
21	1·21	46	552	72	353	98	259	220	115
22	1·15	47	540	73	348	99	257	225	113
23	1·10	48	529	74	343	100	254	230	110
24	1·06	49	518	75	339	105	242	235	108
25	1·02	50	508	76	334	110	231	240	106
	μ	51	498	77	330	115	221	245	104
26	977	52	488	78	326	120	212	250	102

As the measurements of many microscopical objects are given in fractions of an inch in English literature, and in metrical measure in foreign works, the above table has been drawn up to facilitate comparison. Its use is obvious. Examples: 1/7th inch = 3·63 mm., 1/58th inch = 438 μ, or ·438 mm. For fractions smaller than 1/250th inch that portion of the table between the figures 26 and 99 may be used by cutting off the last figure for hundredths, and the two last figures for thousandths. Examples: 1/270th inch = 94·1 μ, or ·0941 mm.; 1/7900th inch = 3·22 μ, or ·00322 mm. When that portion of the table between the figures 100 and 250 is used it is only necessary to cut off the last figure for thousandths. and the two last figures for ten thousandths. Examples: 1/1350th inch = 18·8 μ, or ·0188 mm., 1/16500th inch = 1·54 μ, or ·00154 mm. The conversion of millimetres into fractions of an inch is performed in the same manner; thus, 529 μ or ·529 mm. = 1/48th inch; 39·7 μ or ·0397 mm. = 1/640th inch; 2·62 μ or ·00262 mm. = 1/9700th inch; 1·04 μ or ·00104 mm. = 1/24500th inch; ·977 μ or ·000977 mm. = 1/26000th inch, and so on.—E. M. N

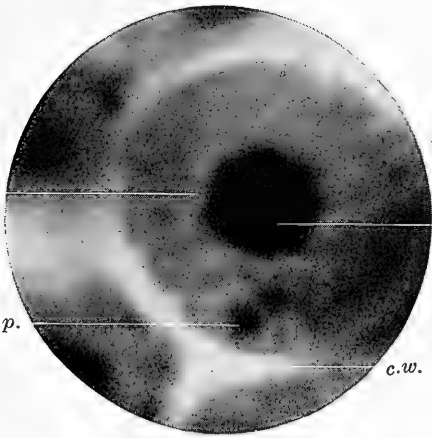


C. D. Soar, del. ad nat.

THE EYE PLATES OF EYLAIS.



1.



2.

J. H. Pledge, Phot.

Cladonia digitata.

Edmund Johnson Spitta,
L.R.C.P. (Lond.), M.R.C.S. (Eng.), F.R.A.S., F.R.M.S

A UNIVERSAL SCALE FOR THE MEASUREMENT OF MICROSCOPE DRAWINGS.

By F. Addey, B.Sc.

(*Read October* 12*th*, 1920.)

Figs. 1 and 2.

It is sometimes necessary, in order to identify a specimen in microscopical work, to measure the length or breadth of an object, and to compare these measurements with those of a drawing or photograph made to some known magnification. The object under observation may be measured either directly by means of a calibrated eye-piece scale, or indirectly by making a drawing of it with the camera lucida, and measuring this drawing by means of a scale formed by marking the divisions of a stage micrometer on a piece of paper, with the camera lucida adjusted as before. If the drawing of the object should happen to be made of the same magnification as the drawing or photograph with which the object has to be compared, the scale is, of course, not required, as dimensions can be compared by direct transference from one drawing to the other by means of a pair of dividers, and they need not actually be known. But in any other case a scale is necessary by which the dimensions of the object shown in the drawing or photograph can be expressed in microns, and so compared with the measurements of the object under observation made by one or other of the methods described. It is, of course, easy to calculate a scale suitable for any particular magnification, but if in the course of any work drawings of many different magnifications should be met with, the labour of calculating separately all the different scales required would become somewhat tiresome.

The following is a description of a simple device by means of which scales for the measurement of drawings and photographs, made to any magnification up to 1,000 diameters, can be at once obtained. It is seldom that drawings are met with of greater magnification than 1,000 diameters; but if it should be necessary to deal with greater magnifications than this, the same principle can be applied to form a universal scale having a range of magnifications as great as may be desired.

The principle on which the scale is constructed is shown in Fig. 1. AB is a centimetre scale of any convenient length, the first centimetre of which is divided into millimetres. Since one micron is 0·001 millimetre, each millimetre will represent one micron magnified 1,000 times. Thus, this scale may be used to measure a drawing made to a magnification of 1,000

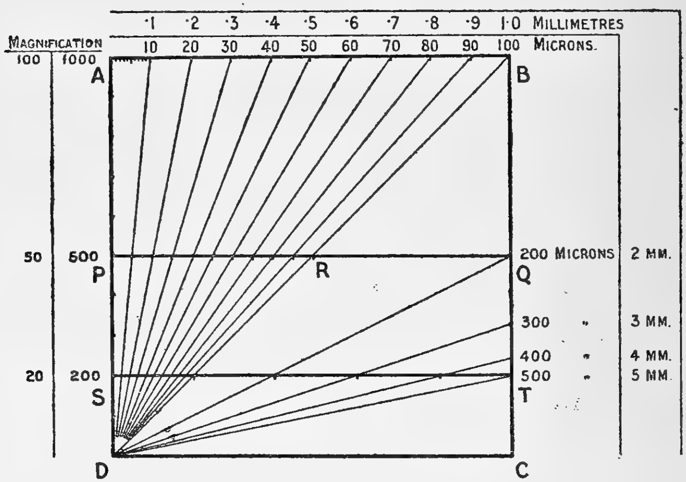


FIG. 1.

diameters, each millimetre on the drawing representing one micron on the actual object.

A rectangle ABCD, of any convenient depth, is drawn on the line AB, and straight lines are drawn from every division of the scale AB to the angle D. For clearness the lines from the millimetre divisions are omitted in Fig. 1. The whole rectangle is thus divided up into a series of triangles, having a common side AD, and bases of varying length.

By bisecting the common side AD in P, and drawing a line PQ parallel to the line AB cutting DB at R, we have, by similar triangles, $\frac{DP}{DA} = \frac{PR}{AB}$. Thus, since DP is half DA, PR is half AB.

In the same manner every division of the line PQ will be half the length of the corresponding division of the line AB.

The length of a division on the line PQ corresponding to a one-millimetre division on the line AB will be half a millimetre, and will therefore be equal to one micron magnified 500 times.

Thus, the line PQ divided in this manner, with the divisions referred up the sloping lines to the figures along AB, forms a scale by means of which drawings of a magnification of 500 diameters can be measured.

By dividing the line AD into ten parts, and drawing through

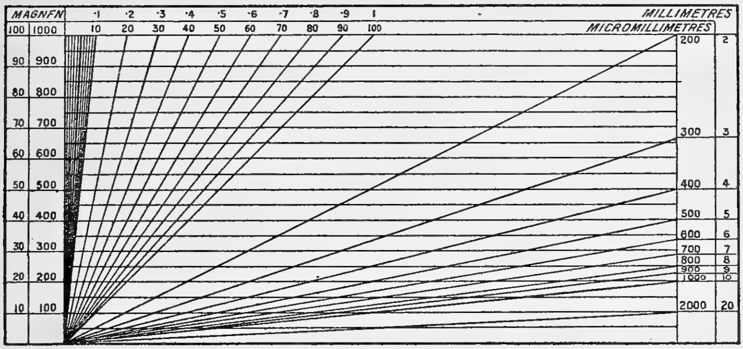


FIG. 2.

each division a line parallel to AB, ten scales are formed for magnifications 1,000, 900, 800, etc., and it is evident that a scale for any intermediate magnification whatever can be obtained by drawing a line parallel to AB through the appropriate point on AD. For example, the divisions of the line ST, drawn through the point S on AD two centimetres from D, give a scale for a magnification of 200 diameters.

With this arrangement, however, the scales for magnifications below 100 diameters are inconveniently crowded together in the lower part of the rectangle. This crowding may be obviated by commencing afresh with the line AB, calling it now a scale for 100 diameters' magnification. Each millimetre on AB will then represent 10 microns, and one centimetre on AB will represent 100 microns, or 0·1 millimetre. The scale represented by the divisions of PQ will then be one of 50 diameters' magnification, and so on for the other scales.

Thus the whole rectangle is used twice over.

To avoid confusion it is convenient to mark the figures for this second series of scales in a different-coloured ink from that used to mark those for the first series.

A photograph of an actual scale made in this way is shown in Fig. 2. On this scale lines have been drawn for magnifications 1,000, 950, 900, 850, etc. (or 100, 95, 90, 85, etc.). For intermediate magnifications it is easy to judge where the corresponding line should be drawn, and the edge of a ruler, or of a sheet of paper, may be placed parallel to the top of the diagram in the proper position to give the scale desired. This is better than loading the scale with a large number of lines.

The sloping lines beyond the diagonal of the rectangle are obtained by extending the division of any convenient one of the lines parallel to AB in Fig. 1, beyond the point at which the line chosen is cut by the diagonal, by the use of dividers, and drawing straight lines through the points so obtained from the bottom left-hand corner of the rectangle to the side corresponding to BC in Fig. 1. The scale numbers along the top line are continued down this side. As an example, the line ST in Fig. 1 has been dealt with in the manner just described.

The side of the rectangle corresponding to AD in Fig. 1 is ten centimetres in length. This is a convenient size, as the divisions for the even tens' or hundreds' magnifications are then spaced one centimetre apart.

SOME METHODS OF PREPARING MARINE SPECIMENS.

By F. Martin Duncan, F.R.M.S., F.R.P.S., F.Z.S.

(*Read November 9th,* 1920.)

In few branches of Natural Science has the microscope been of greater service than in the study of the countless forms of minute plant and animal life which swarm in the sea. Without the help of the compound microscope the true character of those great sheets of grey mud, the Globigerina Ooze, which extend far over the floor of the Atlantic, would never have been made known, and the exquisite structure of the frustules of marine diatoms and the fragile skeletons of radiolarians would have remained hidden from our view; while the extraordinary changes of form through which many marine animals pass in the course of their life would have remained unseen, and the complexity of their life-histories unsolved.

We are singularly fortunate in the rich marine fauna and flora to be found all round our coasts, and although a great deal of work has been done, yet little more than the fringe of the subject has been touched, so that a wide and fruitful field for investigation still awaits the microscopist. It is in the hope of stimulating interest among our members, and more particularly with a view to helping new students of microscopic marine life, that I bring to your notice some of those methods for preserving and preparing marine forms of plant and animal life which have proved, during a period of some twenty-five years of intermittent investigations in Marine Biology, most practical and successful.

The seaweeds well deserve the attention of the microscopist, for there are a great number of small forms whose fruiting organs are singularly beautiful objects under a two-thirds or half-inch objective. Nor are they difficult to obtain: a morning's ramble along the seashore after a heavy gale, more particularly during the autumn and winter, at which season of the year so many of the marine algae bear their fruiting organs, will often supply sufficient material to keep the most ardent microscopist busy for many a long winter evening. On returning from the shore the seaweeds should, if possible, be overhauled and those specimens selected which are intended for mounting as microscopic objects. The rest may be roughly floated on to sheets of cartridge or botanical paper and stored away.

For many years past I have employed the following method, originally devised by my old friend Mr. J. T. Neeve, of Deal, for mounting the fruiting organs of seaweeds: On the work-table have ready three deep, half-plate size stoneware developing dishes, or three ordinary soup-plates. Two of these should be filled with filtered sea-water and the third either with filtered sea-water or tap-water. If red seaweeds predominate, then fill your third dish with sea-water, as some are apt to change colour, or discharge their colouring matter, if placed in fresh water. The whole specimen is first placed in No. 1 dish for a preliminary wash, and while there examined with a pocket lens of × 8 or × 10 for any branches that may bear reproductive organs. These branches are cut off, placed in dish No. 2 and washed, and then carried on to dish No. 3 for final cleansing. When all have been transferred to No. 3 dish, we may at once proceed to mount them, or they may be stored away in a preservative fluid. It is as well, however, to mount at once, even roughly, if circumstances will permit. A 3 in. × 1 in. slip is warmed, a small quantity of Deane's Medium poured on to it, the frond is arranged in position with the help of warmed needles, and a warmed cover-glass then gently lowered from one side on to the slide. The slides are then set aside out of reach of the dust for a couple of days, when the exuded medium can be carefully cleaned off, two or three rings of good gold-size applied, and, when these are thoroughly dry, the mount finished off with a couple of rings of asphalt cement. Deane's Medium can be obtained through any vendors of microscopic reagents, and is a very valuable mounting medium for this work, greatly superior to the ordinary glycerine jelly. It will be found that fronds of seaweeds, and also delicate Mosses, keep their colour well and retain their natural beauty when mounted in this way. Fronds of seaweeds may be stored away in glass tubes filled with a solution of sea-water and formalin, made by adding one part of 40 per cent. commercial formaldehyde to nine parts of filtered sea-water.

If you propose studying the minute cell contents, rather than the external morphology, then you will have to immerse your freshly gathered specimens in one of the fixative solutions used for cytological work. Bouin's solution is a very satisfactory all-round one to employ, and is made up as follows:

Picric acid, aqueous saturated solution	.	75 parts
Formaldehyde (commercial 40 per cent.)	.	25 ,,
Acetic acid	.	5 ,,

After fixation, wash out with alcohols of increasing strength, starting with 25 per cent., stain, dehydrate, clear, and mount in balsam.

To those who wish to study the Hydrozoa and marine Polyzoa with their tentacles fully expanded, it is a very real hardship that, owing to the misuse of hydrochloride of cocaine, even the 1 per cent. solution necessary for narcotisation can only be obtained through a doctor's order. A 1 per cent. solution of cocaine in filtered sea-water is undoubtedly one of the best narcotics for the Hydrozoa and Polyzoa, if perfectly extended specimens are to be obtained. My method of using it is as follows: The organism to be narcotised is placed in a small petri dish containing just sufficient sea-water to cover it and permit of free movement. When the organism has expanded fully, two drops of the 1 per cent. solution of cocaine from a fine pipette are added, and the contents of the dish gently stirred with a clean glass rod, care, of course, being taken not to touch the organism in the process. Stirring is more important when dealing with medusae than with colonies of hydroids or polyzoa. After five minutes, another small dose is added, and this is repeated at regular intervals, until there is no sign of contraction of the body or tentacles on their being gently touched with a needle or fine pipette. The small petri dish, or watch-glass, may then be at once bodily lowered into a larger vessel filled with 4 per cent. formaldehyde solution, which should be allowed to act for not less than five minutes, stirring gently all the time if you are treating medusae, so as to keep them off the bottom. The organism is then removed with as little of the cocaine-contaminated fluid as possible, and placed in a clean vessel containing fresh 4 per cent. formaldehyde, and left for half an hour, after which it is stored in 10 per cent. formaldehyde solution. One important point to remember is that cocaine has a softening action, and therefore the organism should never be left longer in the solution than is absolutely necessary for its complete narcotisation. Chloral hydrate will be found even more objectionable in this respect.

Menthol is a most useful narcotic, and one that deserves to be more widely known and experimented with now that cocaine is almost unobtainable. It is slow in action, and therefore rarely causes the animal to contract, and is most successful with a large number of marine organisms, such as hydroids, echinodermata, anemones, etc. The specimen to be narcotised should be placed in a glass or other dish with sufficient clean sea-water to cover it to a depth of an inch, rather more for a large object such as a starfish or large anemone. The surface of the water is then gently strewn over with crystals of menthol, which will dissolve slowly, and in about twelve to twenty-four hours, according to the size and sensitiveness of the animal, plus the quantity of water in the dish, the fully expanded animal will be sufficiently narcotised to be transferred to a suitable killing fluid, either corrosive sublimate or formaldehyde.

With patience and watchfulness a 70 per cent. solution of alcohol may be successfully employed as a narcotic for some hydroids, but it must be added to the water containing the organism very cautiously and slowly, only a drop at a time from a fine pipette, otherwise contraction will take place.

Weak osmic acid solutions are valuable for fixing marine Protozoa. To a watch-glass full of sea-water containing the Protozoa add a few drops of a ½ per cent. solution of osmic acid and gently stir. The organisms are then allowed to settle, passed into several changes of water, stained, and mounted.

Formalin, properly used, is undoubtedly one of the most valuable preserving fluids for a large number of marine organisms. It can be used with filtered sea-water, and has such powerful antiseptic qualities that quite weak solutions can be employed for preserving delicate structures, nor does it generally produce any serious shrinkage of the tissues. It has one drawback, however, and that is that it completely destroys certain kinds of calcareous structures; therefore it should never be used as a preservative fluid for larval or adult forms of echinoderms or calcareous Sponges. Unfortunately considerable confusion exists as to the actual strength of solutions, owing to the indiscriminate use of the terms formaldehyde and formalin by many authors. 10 per cent. formalin and 10 per cent. formaldehyde are by no means one and the same thing, for the latter is two and a half times the stronger. Commercial formalin contains a definite quantity of gaseous formaldehyde, which is generally stated on the manufacturer's label either as formaldehyde 40 per cent. or 30 per cent. The percentage should always be ascertained at the time of purchase, and then it is a simple matter to make up the solutions. Thus a 10 per cent. solution of formaldehyde is made by adding 300 c.c. of water to 100 c.c. of the stock formaldehyde 40 per cent., and this will be found a very useful standard solution for general purposes. I always keep on my work-table two standard solutions, namely, the 10 per cent. and a 4 per cent. solution made by adding one part of formaldehyde 40 per cent. to nine parts of water. The 4 per cent. solution will be found most useful for preserving many delicate organisms; while fish-eggs and embryos are best mounted in deep cells filled with this solution.

Amphipods, copepods, and the larval stages of the Stalk-eyed Crustacea may be killed with 4 per cent. formaldehyde in sea-water, and then transferred to 70 per cent. alcohol. All the Crustacea require careful handling in staining, as they easily over-stain. It is preferable to use either a weak alcoholic picro-carmine, or Mayer's alcoholic cochineal stain, the latter often giving very beautiful results. After staining and dehydrating, clear the Crustacea in Turpineol, which does not render the specimens too transparent, but beautifully translucent. From the Turpineol the specimens may, with advantage, be washed in xylol before mounting in xylol-balsam.

Sponges brought home from the rocks in a jar of sea-water are taken out and plunged into a 1 per cent. solution of osmic acid, and left for five minutes or longer according to size, and are then placed in strong alcohol, which should be changed two or three times.

Sections stain nicely with Mayer's alcoholic cochineal.

The larvae of Spongilla are allowed to settle down on a large cover-glass, and then fixed for three minutes in absolute alcohol. They are then stained in alcoholic carmine, passed through graded alcohols, cleared in oil of bergamot, and mounted in balsam. This is the original method employed by Delage.

The following is a method used for many years in cases where time has been limited, for the wholesale preserving of the tow-net catch:

The receptacle to contain the catch consists of a glass pickle-jar of some half-gallon capacity, with a good, deep, tight-fitting cork. Through the cork two cleanly cut holes, about three-quarters of an inch in diameter, are bored, and into one of these a piece of brass tubing six inches in length is tightly fitted, so as to project on either side of the cork. To that end of the tube which will project within the jar a loose coil of wire, consisting of about half a dozen turns, and about two inches diameter and four inches long, is firmly soldered. Over the loose coil is securely fastened to the tubing a small bag of fine muslin or bolting-silk. The end of the tubing outside the jar is bent at an angle like a spout. Into the second hole is tightly fitted a stout japanned iron funnel, having a rim eight to ten inches in diameter. Into this funnel the contents of the " can " at the bottom of the tow-net is emptied each time it is drawn inboard, and while the waste water flows out through the brass tube, the little muslin or bolting-silk bag prevents the escape of the animals, and the coil of wire keeps the bag expanded and the animals from becoming jammed against the tube by the outrush of water.

The catch may then be emptied into a smaller glass jar, and while stirring gently with a glass rod, so as to keep the organisms on the move, a small quantity of 4 per cent. formaldehyde is added. After stirring for about five minutes allow the plankton to settle at the bottom of the jar. When the jar is not more than half-filled with the plankton, pour off as much of the fluid as possible and fill up with 4 per cent. formaldehyde, giving a good stir round so as to thoroughly mix. Each store jar should never be more than half filled with plankton; if the jar is then filled up to the top with the formaldehyde solution, the organisms will keep all right. It is necessary the following day to pour off the 4 per cent. solution, and then fill up with 10 per cent. formaldehyde. Cork down tightly, and the specimens will require no further attention, and are ready at any time for examination.

As a cement and varnish for ringing slides I use one composed of equal parts of best asphalt varnish and best marine glue, plus three drops of castor oil to each ounce of mixed cement.

I first ring the slide with gelatine (applied warm), and when that has set, paint over with a strong solution of potassium bichromate liberally applied so that it is soaked up by the gelatine; expose slide to daylight for an hour, which will render the bichromated gelatine insoluble; then finish off with two or three good coats of the asphalt-marine glue cement, taking care that each coat is thoroughly dry before applying another.

FLUID MOUNTING.

By E. D. Evens.

(*Read December 14th*, 1920.)

It is generally recognised by microscopists that fluid mounts are uncertain. Occasionally a few stand good for many years, particularly those in which the preserving medium is glycerine; but the majority of aqueous mounts develop air bubbles which gradually enlarge and the object is spoilt.

If a fluid mount which has been put up for a year or two be held in the hand and the reflection of a bright object in the cover-glass examined, it will generally be found to be distorted, the cover-glass presenting a concave surface. This shows that the liquid must be escaping and as a consequence the internal pressure in the cell has fallen below that of the atmosphere. When the internal pressure reaches the vapour pressure of the medium a bubble will form, a bubble, for instance, of water-vapour, containing any dissolved air which may have been originally in the liquid.

This loss of liquid can only occur by its absorption in the cement of the cell and ring and by its evaporation from this into the air. Water is slightly soluble in most oils and varnishes, as much as 5 per cent. being absorbed in many cases (*vide* Dr. R. G. Morrell, *Oil and Colour Chemists' Ass.*, February 12th, 1920). Hence the ring of varnish acts like a semipermeable membrane, absorbing the water on one side and evaporating it on the other.

If this be the true explanation of "leakage" it is obvious that it is necessary, in order to prevent it, to find some sealing material in which water is insoluble or nearly so. If this material is not mechanically strong it is unimportant, as, after sealing, other cements can be put on to give the necessary durability.

Of all the cements on the market, gold-size, brown cement, Bell's cement, etc., none will stand a week's immersion in pure water even when quite hardened. Shellac, brown cement, etc., become elastic and lose their hold on the glass and can be peeled off as a sheet by placing a knife under one edge. Gold-size and Brunswick black, on the contrary, become extremely brittle, and flake off when touched.

J. Sinel (*Outline of the Natural History of our Shores*, page 305) recommends a mixture of vulcanised rubber and paraffin wax for sealing museum jars, and it occurred to me that this might be a suitable material for microscopic purposes.

On trying it, however, it was found unsatisfactory, as in a short time after manufacture it changed in some way, causing it to char and not melt when heated. It was then suggested that unvulcanised raw rubber should be tried, and this was found very satisfactory.

Best Para "Bottle" rubber is cut into small pieces and added to eight times its weight of paraffin wax (m.p. about 50° C.) and melted in a water-bath. It is kept at 100° C. until the whole of the wax has been absorbed by the rubber, which by this time will have swollen up enormously; the time required is from 12 to 24 hours. The temperature should then be raised to about 175° C. or until the mixture just begins to smoke. In about thirty minutes it will gradually melt down to a clear liquid. Four and a half parts of dry dammar resin are now stirred in and the whole thoroughly mixed. The gum dammar hardens the cement when cold and makes it more fluid when hot.

Paraffin wax (m.p. 50° C.)	8 parts
Para ("Bottle") rubber	1 part
Gum dammar	4½ parts

I call this mixture, from the initial letters of its components, D.I.P. cement.

The bulk of this is composed of paraffin wax, and, since the solubility of water in it is very small, it should make a much more satisfactory first coat than, say, gold-size; and, in fact, a layer melted on to glass is very much less affected by water than any other known cement. Pure paraffin wax floats off after immersion in water for a few hours.

In order to make a cell of this D.I.P. mixture some of it is melted in a tin, getting it as hot as possible without allowing it to smoke. A clean glass slip is then heated over a spirit lamp, placed on the turntable, and a ring of the cement spun as quickly as possible on it. If the temperatures have been arranged properly this ring will remain melted on the slip for a few seconds and will then solidify. Further rings may now be added till the cell is deep enough.

After cooling completely the cell should be turned down to a smooth upper surface, and to the required depth, using a sharp knife and spinning the table rapidly just as if one were turning a piece of wood in a lathe. The cell is now filled with the mounting medium, the object arranged, and the cover-glass pressed down. All the excess of fluid from under the cover should be carefully absorbed with blotting-paper until it is firmly held down by capillary attraction. Now, with a hot needle and some small scraps of D.I.P. cement, the edge of the cell should be sealed to the cover-glass, a bit at a time, taking it just, and only just, over on to the top of the cover. During this process it is necessary at intervals to suck out more of the fluid with blotting-paper as the cover-glass settles into its position. If this is not done the liquid will come into contact with the hot needle and make a bad joint. Should this occur the cement must be scraped off for about the eighth of an inch on each side, the cover-glass dried and resealed. This is a very important point, as the steam from the hot liquid appears to have the property of preventing the cement getting a hold on the glass. The angle between the cover-glass and the ring must be completely filled up so that the former is really embedded in the cell wall. The ring should now be trimmed with a knife and the slide and cover-glass very carefully cleaned. It may be left in this condition for a year or so as a temporary mount. For a permanent mount it should now be given two rings, at intervals of a day or two, of a spirit shellac varnish to protect the wax from the solvent action of the next ring, taking care to completely cover the whole of the D.I.P. cement from glass to glass.

The shellac mixture used is :

Best orange shellac	20 grammes
90 per cent. alcohol	100 c.c.

Dissolve and filter out the insoluble flocculent matter. This is a slow process, and may be hastened by using a filter pump. To the clear orange solution add :

Castor oil	1·8 c.c.
Camphor	4·0 grammes

and allow to evaporate to the right consistency.

The camphor and castor oil remove brittleness and prevent sweating. The whole slide, ring and cover should now be thoroughly cleaned from wax and grease with xylol, the shellac protecting the ring.

After hardening for a week or a fortnight, several good rings of gold-size should be applied. I generally use a gold-size containing indiarubber, composed of:

Gold-size	2 volumes
3 per cent. rubber in benzene . . .	1 volume

Let this stand in an uncorked bottle until the two have mixed perfectly to give a clear brown liquid. The slide should now be put away for six months or so to harden off and can then be finished with a coat of Brunswick black, followed by one of gold-size. It is advisable to give it a further coat of shellac after two or three years to prevent complete hardening of the gold-size.

This D.I.P. cement is suitable for dilute formalin, pure or dilute glycerine, glycerine jelly, etc. It will also resist saturated aqueous potassium mercuric iodide solution. It is, of course, not suitable for oily media like paraffin oil, balsam, etc. It ought to be satisfactory for strong alcohol, but in this case it would be better to omit the gum dammar and replace the two shellac coats by two of gum arabic containing a little glycerine.

The argument often used against fluid mounts, viz. that the difference in the expansion of the fluid and the cell under the influence of heat will upset any cement ring, is, I believe, false. The actual difference is an exceedingly minute quantity and there is ample allowance for it in the elasticity of the cover-glass, which acts as the stretched membrane of a drum, taking up any small change in the volume of the liquid without an undue increase in pressure.

This method has been in use only for about four years, and of course it is too early as yet to pass judgment upon it; but up to now no failures have occurred.

It is possible that the rubber-paraffin mixture might with advantage be replaced by a guttapercha-paraffin mixture, as water dissolves in guttapercha only to the extent of about 1·5 per cent, while the corresponding figure for rubber is 10–12 per cent. The value of this suggestion, however, can only be tested by experiment.

[*Note.—August* 1921.—Since the above was written I have tried this guttapercha-paraffin compound and do not think it appears more promising than the original, as it seems more brittle. I also now think that the gum dammar in the D.I.P. cement may with advantage be reduced to half the value given above, i.e. to two parts, for eight of wax and one of india-rubber.]

MOUNTING FRESHWATER ALGAE, MOSSES, ETC.

By E. D. Evens.

(*Read December* 14th, 1920.)

Mounted specimens of freshwater algae are not often met with, due to their generally unsatisfactory character. For the minute study of their cell contents, stained and mounted specimens are indispensable, but for the rapid recognition and identification of living plants these are not always satisfactory, and a series of type-mounts of freshwater algae preserved in their natural green condition without shrinkage would be very useful.

A great many different fluid media have been recommended for this purpose, most of them employing a copper salt for the preservation of the chlorophyll. Chlorophyll is a complex ester or mixture of esters, containing a small amount of magnesium. Both acids and alkalis rapidly split it into its alcoholic and acidic components, the former also removing the magnesium. Hence fluids to preserve chlorophyll unchanged must be neutral. Magnesium–chlorophyll is at best an unstable substance, but by treating it with solutions of various acetates the corresponding metals may be made to replace the magnesium, producing much more stable compounds (**1**). The copper derivative is one of the most stable, and this is the reason why cupric acetate is usually present in fluids recommended for the preservation of green plants (**2**), (**3**), (**4**). Plants treated with copper salts have a rather bluish-green colour and do not bleach out in bright light, but are found to show a good deal of shrinkage unless the solutions used are very dilute. The copper salts must be thoroughly washed out and the object mounted in a neutral medium such as 5 per cent. formalin which has been standing over chalk or, better, in pure glycerine. If the mounting medium contains copper, sooner or later round black or red globules are deposited all over the cover-glass and object, varying in size from a mere point to half the size of a pin's head. These sometimes form in a few days after the mount has been sealed, sometimes they take several months to appear. By reflected light the opaque red ones are evidently metallic copper, and the brownish transparent ones appear to be cuprous oxide, both being formed by the reducing action of organic matter on neutral copper salts (cf. the action of sugar on Fehling's solution). The only way to prevent this is to thoroughly wash out the fixing liquid.

Many solutions containing copper salts have been recommended in the past, of which the best known are Ripart and Petit's (**5**), Julien's (**6**), Harris's (**7**) (**8**), West's (**9**), the glycerine-camphor-water-copper-acetate mixture (**10**).

My own method consists in fixing the plant for 24 to 48 hours in a solution containing $^1/_2$–3 per cent. formaldehyde (say, 1–8 per cent. formalin), and 0·1–0·5 per cent. copper acetate. The presence of camphor as sometimes recommended is injurious to the colour. The material should then be well washed for three to four hours in many changes of water and placed in $2^1/_2$–5 per cent. glycerine, together with a crystal of thymol. This is allowed to evaporate in a warm place, the last traces of moisture being removed by placing it in a desiccator over calcium chloride. The object is then mounted in pure glycerine. The strengths of the various solutions and the time of evaporation (two days to two months) must be adjusted by trial in each case so as to prevent shrinkage.

In the paper (**1**) by Jörgensen referred to above, it is suggested that zinc acetate might prove to be better than copper acetate for museum specimens of large plants, although the zinc-chlorophyll compound is not quite as stable as the copper one. I have tried this for algae, mosses, etc., and have found it very satisfactory, the colour being almost identical with that of the fresh plant, while there is less tendency to shrinkage. I now use it to the complete exclusion of the copper method.

The fixing solution is:

5 per cent. neutral formalin (2 per cent. formaldehyde)	10 c.c.
10 per cent. zinc acetate in thymol water .	1 c.c.

For delicate objects dilute with an equal volume of distilled water. Fix for two to three days in the dark. It is advisable to wash out the zinc salts with 5 per cent. formalin or distilled water for two or three hours after fixing, when the object may be mounted direct in 5 per cent. neutral formalin or placed in dilute glycerine with a crystal of thymol and allowed to evaporate in the dark as before. Mount in pure glycerine or in glycerine jelly. This method preserves the cell contents well, e.g. it shows the suspended nucleus in Spyrogyra and the cilia of Volvox.

There is no doubt that glycerine shows up the green colour and preserves it better than aqueous media, but it is often difficult to get delicate objects into glycerine without shrinkage, e.g. Vaucheria and its zoospores. In this case, formalin or thymol water or the formalin-zinc-acetate fixing solution may be used as the mounting medium. The green colour does not fade in either case in the dark, but the aqueous mounts bleach out quickly in direct sunlight, while those preserved in glycerine keep their colour perfectly, even after weeks of exposure to bright daylight. In a few cases this method, as well as the copper one, fails completely, the colour changing to a dirty brown during fixation, e.g. in some delicate leafy liverworts, some fern prothallia and often in Spirogyra and Zygnema.

In some cases (Micrasterias, Cladophora) small dark spots are deposited on the object during fixation, much resembling those occurring in the copper method, only rather smaller; and I find it very difficult to conjecture of what they can consist. The only other zinc salt which I have tried is zinc salicylate, and this produces the same effect. In such cases it is advisable to cut down the time of fixing as much as possible and to make the subsequent washing very thorough.

The above method is suitable for algae, mosses, liverworts, prothallia of ferns and equisetaceae, selaginella and higher plants, green hydrae, etc.

It is a great advantage with mosses and other aerial plants if the water used for diluting the concentrated formalin for the fixing liquid has been recently boiled and cooled, as it will then quickly dissolve any air about or within the leaves, etc., and allow the fixing fluid to penetrate rapidly. It must not be boiled *after* the addition of the zinc acetate, as this causes hydrolysis with the precipitation of white gelatinous zinc hydroxide.

I strongly recommend the boiling of all botanical fixing solutions that will stand it, such as chromacetic acid, as it increases the penetrative power. The object should be placed in a bottle and the cooled fluid poured in until it is overflowing, when the cork may be pushed home so as not to include any air. The material floats at first, but sinks as the entangled air is dissolved.

The neutral formalin required in the above method may easily be obtained by keeping a lump of chalk in the bottle of strong formalin.

The fixing and staining of algae have been very ably dealt with by Professor C. J. Chamberlain in his *Methods in Plant Histology* (Chicago, 1915), to which anyone interested in this branch of research is referred. The results obtained by staining with Magdala red and aniline blue, as he directs, are exceedingly beautiful, and it may perhaps be worth while to point out here that the Magdala red used in the process is apparently identical with eosin. The aniline blue which has been found most satisfactory is the mono-sulphonated water-soluble aniline blue known as alkali blue (B.A.S.F.). I also find paraffin (Burroughs and Wellcome's Parolein), as recommended some years ago by Dr. A. Cole, to be a satisfactory mounting medium in place of Venice turpentine.

REFERENCES.

(1) *Nature*, 1916, **98**, 229, I. Jörgensen.
(2) *Kew Bulletin*, 1908, Prof. Trail.
(3) *Nature*, 1916, **98**, 191, A. B. Rendle.
(4) *J.Q.M.C.*, 1917, **13**, 2nd series, 344, A. B. Rendle.
(5) See *The Microscope*, 1901, 519, Carpenter.
(6) *Journ. New York Mic. Soc.*, 1893, **9**, 39, Julien (abstracted *J.R.M.S.*, 1893, 566).
(7) *J.Q.M.C.*, 1915, **12**, 2nd series, 527, G. T. Harris.
(8) *J.Q.M.C.*, 1916, **13**, 2nd series, 15, G. T. Harris.
(9) See a *résumé* by Nieuwland, *Bot. Gaz.*, 1909, **47**, 237 (abstracted *J.R.M.S.*, 1909, 401).
(10) E.g. see Cross and Cole's *Modern Microscopy*, 1912, 189.

See also :

Museum Journal, 1914, April, 325.
Museum Journal, 1916, October.
Bot. Gaz., **24**, 206.
J.R.M.S., abstracts, 1894, 277, Lemaire.
Guide to Microscope, Heath, 114.

[*Note.—August* 1921.—I have since found that it is advisable to fix very delicate objects, such as Protococcus, for a few minutes by adding to the water containing them one-fifth of its volume of Flemming's weaker solution. This should then be well washed out with weak formalin before proceeding with the zinc acetate-formalin treatment. This causes very little blackening. None of the fixing agents above described are ideal, and all cause shrinkage in Cladophora.]

NOTES ON PARASITIC ACARI.

A. On the Presence of a System of Tracheal Tubes in the Families Sarcoptidae and Listrophoridae.

B. Note on the Two Valid Species of the genus Psoroptes (P. natalensis *and* P. communis).

BY STANLEY HIRST.

(*Published by Permission of the Trustees of the British Museum.*)

(*Read June* 14th, 1921.)

FIGS. 1–3 IN THE TEXT.

A. ON THE PRESENCE OF A SYSTEM OF TRACHEAL TUBES IN THE FAMILIES SARCOPTIDAE AND LISTROPHORIDAE.

THE mites of the families Sarcoptidae and Listrophoridae are considered by the great majority of authors to belong to the order Astigmata, chiefly characterised by the absence of stigmata and of tracheal tubes. It is true, however, that Mégnin figures a supposed stigmata in *Chorioptes ecaudatus* (see fig. 7, pl. xxi. in *Parasites et Maladies Parasitaires*), and in a recent paper (*Bull. Soc. Zool. Paris*, 1916, p. 61) Trouessart affirms his belief in the presence of stigmata in Analgesidae and Sarcoptidae. The presence of tracheal tubes in Acari of these families has not yet been recorded, however. Whilst examining a preparation of *Otodectes cynotis* var. *cati* kindly lent the author by Dr. J. H. Ashworth, of the University of Edinburgh, it was noticed that distinct tracheal tubes distended with air were clearly visible in three of the mounted specimens, and it was possible also to trace them in specimens of the variety *furonis* (from ferrets). The distribution and general appearance of the system of tracheal tubes in *Otodectes* is shown in fig. 1. It will be seen that there is a tube on each side of the body, running posteriorly at least as far as the fourth leg; anteriorly each tube extends far forwards, being coiled in a complicated manner near the second leg, and there is another little coil near the first leg; apparently the orifice is somewhere above this limb. The author has not been able to see tracheal tubes in any other Sarcoptid mites,

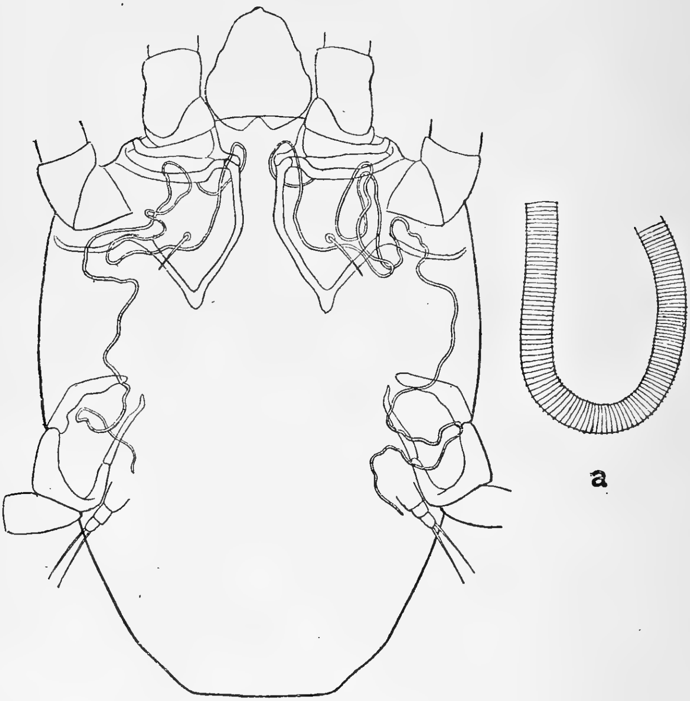


Fig. 1.

although an extensive series has been examined. This may be due to the fact that the tracheal tubes are very fine and difficult to see unless filled with air. On the other hand, it is possible that the mites of this family may have descended from ancestral forms in which a tracheal respiratory system was present, but which has disappeared in all the genera except *Otodectes*.

In the Listrophoridae tracheal tubes are present in *Chirodiscoides caviae* mihi and also in an undescribed Listrophorid mite occurring on *Cricetomys gambianus*. In the latter species of mite there is a slender striated tube on each side running almost

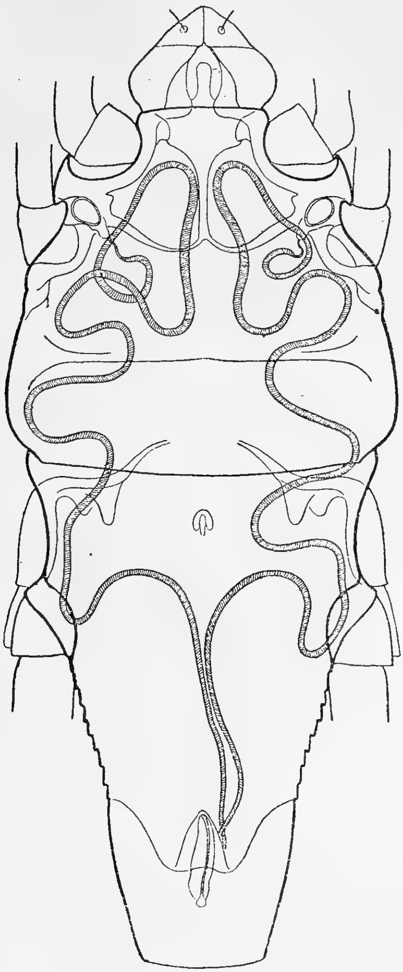


Fig. 2.

the entire length of the body (see fig. 2). Each tube curves several times and finally terminates as a small coil, becoming greatly narrowed and apparently opening through a stigmal aperture situated laterally (on each side) between the first and second pair of legs. Posteriorly the tubes apparently do not join with one another, terminating separately near the anus.

B. Note on the Two Valid Species of the genus Psoroptes (P. natalensis and P. communis).

Apparently there are only two valid species of *Psoroptes* (*P. natalensis* mihi and *P. communis* Fürstenberg). They differ from one another in the shape of the hairs on the abdominal lobes of the male. The author has not been able to examine specimens of *Psoroptes gazellae* Canestrini (off *Gazella* sp., locality not known) and so cannot say anything about this form. The measurements in this note have been made with a No. 2 "stufen" micrometer; the drawings were done by Mr. Percy Highley with an Abbé camera lucida.

Psoroptes natalensis Hirst.

Psoroptes natalensis Hirst, *Ann. Mag. Nat. Hist.* (9), iii, 1919, p. 524.

Hirst, *Ann. Mag. Nat. Hist.* (9), vii, 1921, p. 39.

In *Psoroptes natalensis* mihi the middle hair on the abdominal lobes of the male is long and fine; the hair on each side of it is also long, but the distal half is slightly flattened (blade-like). This species can be easily recognised by these two modified hairs. The outer hairs on the lobes are quite short.

This mite has so far only been found at two localities, viz. (1) Richmond, Natal (mounted specimens presented to the British Museum, Nat. Hist., by Mr. C. D. Soar); (2) at Paris on a buffalo in the menagerie of the Museum (specimens mounted by P. Mégnin, kindly lent the author for examination by Dr. M. Langeron, of the Laboratoire de Parasitologie, Paris University).

Measurements.

	Ovigerous female.	Pubescent nymph.	Male.
Locality: Richmond, Natal.			
Length . .	510–599 μ	470–480 μ	375–422 μ
Width . .	357–420 μ	340–350 μ	285–317 μ

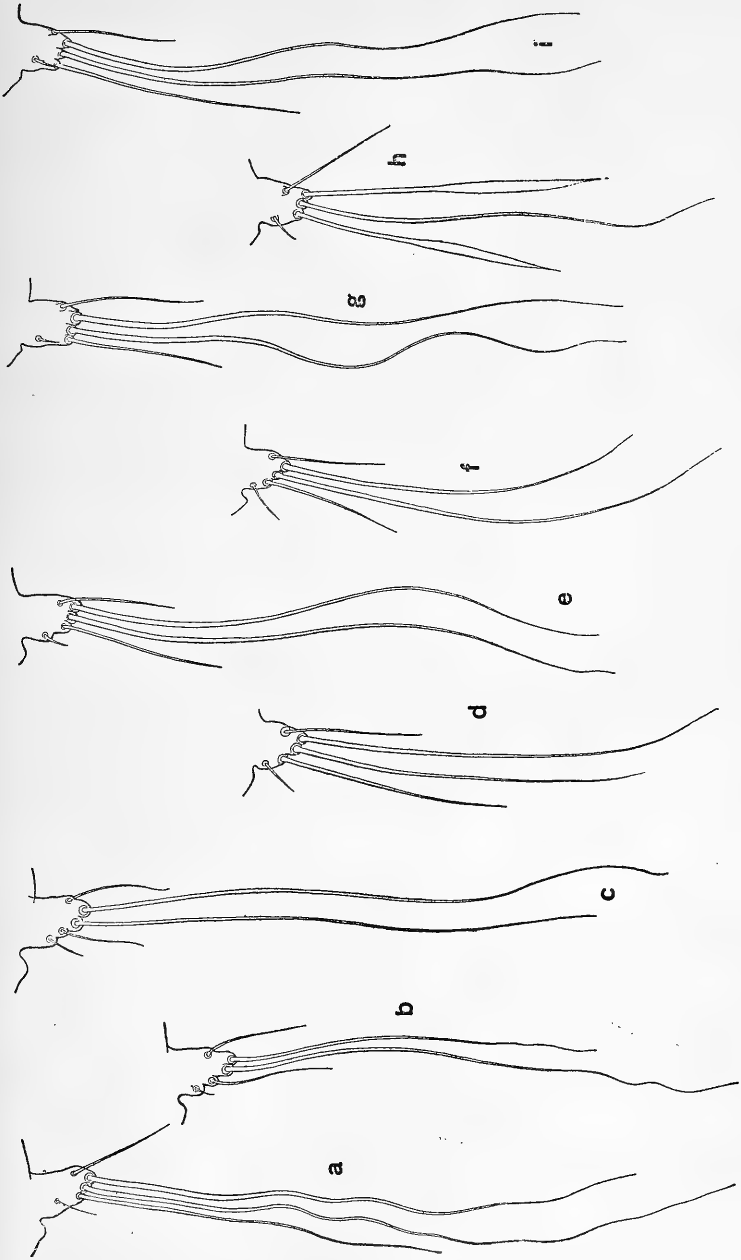


Fig. 3.

Locality: Museum Menagerie, Paris (on a Buffalo from Cochin China).

	Ovigerous female.	Pubescent nymph.	Male.
Length . .	—	450 μ	480–510 μ
Width . .	—	312 μ	332–340 μ

Psoroptes communis Fürstenberg.[1]

I have examined a large series of specimens of *Psoroptes* from various domestic animals and can find very little structural difference between them. It seems certain that the mites of this genus (with the exception of *Psoroptes natalensis*) must be regarded merely as races or slight varieties of a single species.

The same appears to be the case in the genus *Sarcoptes*, for I have examined specimens from a number of hosts, viz. man, dog, fox, rabbit, guinea-pig, pig, goat, cattle, hartebeest, kudu, coatimundi (South American carnivore) and lion, without being able to discover a single constant structural character by which they can be separated from one another. There seems, indeed, to be only a single species in the genus *Sarcoptes*.

Although differing so little in structure, various observers have pointed out that it is very difficult to transmit mites of the genus *Psoroptes* from one host to another of a different species. For instance, Delafond and Bourguignon failed to transmit *Psoroptes communis* var. *ovis* to any other host.

The hairs on the abdominal lobes of the male (fig. 3) are all normal in appearance in *P. communis*, none of them being in the least flattened or blade-like. Two of the hairs (the third and fourth from the outer side of the lobe) are always much longer than the others. In specimens from horses the second hair from the outer side of the lobe is usually longer than in the other races or varieties of *P. communis*. In specimens from cattle this hair is rather long, but not nearly so long as in var. *equi*. In the variety *cervinae* (from the Bighorn; H. B. Ward's coll.) it is variable in length, sometimes being rather long. In the variety *cuniculi* it is much shorter and finer at the base than in the var. *equi*.

[1] For the principal literature on this species see Railliet, *Traité de Zoologie Médicale et Agricole*, 2nd edition, Paris, 1895, p. 666.

In the varieties *ovis* and *caprae* it is about the same length as in var. *cuniculi.*

When the locality is not mentioned in the list of measurements given below the specimens are European.

MEASUREMENTS.

	Ovigerous female.	Pubescent (female) nymph.	Adult male.
Var. *equi.*			
Length . .	512–745 μ	345–556 μ	407–560 μ
Width . .	350–480 μ	280–420 μ	290–365 μ
Var. *ovis.*			
Length . .	610–690 μ	393–510 μ	460–610 μ
Width . .	—	—	330–410 μ
South African specimens of var. *ovis.*			
Length . .	435–685 μ	—	420–585 μ
Width . .	—	—	315–405 μ
Var. *cuniculi.*			
Length . .	520–830 μ	400–430 μ	470–720 μ
Width . .	375–580 μ	—	310–420 μ
African specimens of var. *cuniculi.*			
Length . .	653–700 μ	392–420 μ	545–630 μ
Width . .	370–390 μ	—	330–370 μ
Var. *caprae.*			
Length . .	—	—	610–650 μ
Locality: Cape Vincent, West Indies.			
Length . .	525–612 μ	440–480 μ	430–505 μ
Locality: Sonora, Texas (F. C. Bishopp).			
Length . .	460–580 μ	310–360 μ	440–470 μ
Var. *bovis.*			
Locality: Amarillo, Texas (F. C. Bishopp).			
Length . .	630 μ (only one specimen measured.)		470–480 μ
Width . .	432 μ	—	330–345 μ
Locality: Johannesburg.			
Length . .	—	—	440–490 μ
Width . .	—	—	325–340 μ
Locality: Colorado. Var. *cervinae.*			
Length . .	515–675 μ	—	515–570 μ
Width . .	—	—	330–370 μ
Var. from Ibex (locality unknown: Burrows Coll., Lister Institute).			
Length . .	740 μ (one specimen only)		
Width . .	415 μ		

FIGURES IN TEXT.

Fig. 1. *Otodectes cynotis* var. *cati*, showing distribution of tracheal tubes; (*a*) portion of tube greatly magnified to show striation.

,, 2. Listrophorid mite (undescribed genus occurring on *Cricetomys gambianus*), showing distribution of tracheal tubes.

,, 3. Posterior abdominal lobes of males of *Psoroptes*: (*a*) *Psoroptes communis* var. *equi*; (*b*) var. *ovis*; (*c*) var. *cuniculi*; (*d*) var. *bovis* (from Johannesburg, South Africa); (*e*) var. *caprae* (Cape Vincent, West Indies); (*f*) var. *bovis* (from Amarillo, Texas); (*g*) and (*i*) var. *cervinae* (Colorado); (*h*) *Psoroptes natalensis* Hirst.

NOTICES OF BOOKS.

Contributions to the Biology of the Danish Culicidae. By C. Wesenberg Lund. pp. 210 + 21 plates + 19 figs. in text. $10\frac{1}{2}$ inches × $8\frac{1}{2}$ inches. (*Memoirs of the Royal Academy of Sciences.*) (Copenhagen: Andr. Fred Host & Son, 1920–21.)

Dr. Wesenberg Lund in his introduction to the above monograph makes the following statement with regard to the methods of research to be followed: "He who has first crammed his head with all that has been written upon a subject will at the moment of observation, when standing face to face with nature, soon understand that his whole learning is only felt as a burden and restricts his power of observation. I for my own part have always been of the opinion that it is exactly the smallest equipment of human knowledge which gives the greatest peace in my studies, creates the scientific sovereignty over observation and thought, and—as far as possible—moves the milestones of time nearer to the borders of eternity." This seems a counsel of perfection hard to follow under modern conditions of work. For if we are not to benefit by the pioneer work already done in any subject, the years may find us laboriously cutting tracks through regions of knowledge already explored and mapped by the early workers.

The author's researches into the life-history of the Danish Culicidae, which were carried out during several years, involved the description of the anatomical details of the larval forms and keeping them under observation in specially devised tanks in the laboratory. By this means he was able to reach definite conclusions not only as to the interrelationship between the larval forms and imagines, but also to prove that some of the species (4) living in Denmark were of American origin and had not hitherto been recorded from Europe. Not the least interesting result of his researches, and one that gave him great delight and was of prime importance, was the presence of the tropical form Taeniorhyncus, which by its mode of respiration—with its siphon pierced into the tissue of the water-plants—is able to continue as a larval form during the rigours of a Danish winter. Thirteen new species were added to the Danish fauna, making twenty-five in all.

It is of great interest to note that this valuable memoir issued under Danish authority is yet written in English. The plates are very beautifully produced and are from careful original drawings by the author. To anyone engaged on similar researches on a special group of insects we can cordially recommend this monograph as an example to be followed in the presentation of his results.

The Elements of Vegetable Histology. By C. W. Ballard. pp. xiv + 246 + 75 figs. in text. 8 × 5½ inches. (New York: John Wesley & Sons Inc. London: Chapman Hall, Ltd., 1921. Price 18*s*. net.)

The author of the above book is Associate Professor of Materia Medica and Director of the Microscopical Laboratory at Columbia University, and it embodies his experience gained as a teacher of the needs of the student who intends later to specialise in the micro-analysis of foods. The volume is intended for the beginner and to provide a practical laboratory guide in the subject. In many instances details have been omitted in order to avoid confusion in the mind of the student, a knowledge of general principles as a groundwork for further study being aimed at. The importance of laboratory work is properly emphasised, as the personal equation is of much importance in the right interpretation of findings in the micro-analysis of foods. There are chapters devoted to the preparation of specimens and the chemical reaction of plant tissue, of microscopic technique and the use of the microscope. The chapters devoted to Vegetable Histology are arranged under the headings of the various tissues described and under root, stem, leaf, flower, fruit and seed structures. In each, practical details are given for the preparation and examination of fresh and stained material. The chapters describing root and stem structure are particularly praiseworthy in the way a very intricate subject is dealt with. Numerous illustrations are introduced from original drawings, which are intended to show the important details to be noted by the student while examining the material under observation.

An appendix provides useful formulae and data, and a list of books for further reference.

THE MICROSCOPE IN THE MILL: Formation, Chemistry and Pests of Corn, Meal and Flour. By James Scott. pp. x + 246 + 124 figs. in text. (Liverpool: The Northern Publishing Co., Ltd.)

THE contents of the above book are arranged in twenty-six chapters which have appeared as serial matter at various times in the pages of *Milling*. This leads to the appearance of discontinuity in the treatment of the matter, as each chapter is more or less independent. The author would have been well advised in removing this serial character if only to the extent of numbering the figures consecutively. The author has obtained his material from direct observation and experiment on the objects and substances described, the illustrations being exact reproductions of the original drawings. To those engaged in the milling industry the book may provide useful information where work of a microscopic character is carried out. The micro-analyst of cereal foods would find it useful in the detection of adulteration and in the analysis of mixtures. The titles of some of the chapters will sufficiently indicate the scope of the book: The Microstructure of Wheat, of Barley, of Maize; Oatmeal Microscopically Considered; The Proteids of Flour; Saccharification of Starch; Ergot; Micro-fungi of Grain; Rope in Bread; The Wheat Midge; Corn Saw-fly.

FIFTY-FIFTH ANNUAL REPORT.

In presenting their Report for the year ending December 31st, 1920, your Committee feel that there is room for satisfaction in the condition of the Club, which shows renewed vigour and increase in membership. During the year the number of new members elected has been fifty-six, a number which has only once been exceeded (in 1906). There have been seventeen resignations, and nine members have been removed by death. Among these is Mr. Wynne E. Baxter, whose name is familiar to microscopists as the translator of Dr. Van Heurck's work on the Diatomaceae.

In November the Club learnt with regret of the accidental death by drowning of Mr. Robotham, a keen and promising member, who rendered useful service as Assistant Secretary in the early part of the war. By the death of Mr. F. Oxley the Club loses one of its oldest members; while Mr. L. E. Harris was killed in France. Other members deceased during the past year are Messrs. C. E. Hearson, T. L. Burrell, W. C. Flood, G. E. Mainland and F. Melhuish. In addition it is with regret the Club learns, during the last month, of the death of Mr. T. A. O'Donohoe, I.S.O., well known as a microscopist and photographer, who made a special study of the Blow-fly's "tongue," and particularly excelled in preparing mounted specimens. Dr. E. J. Spitta, past-President of the Club, died on January 21st, 1921, one to whom the Club is much indebted in many ways. His book on microscopy, which has passed through three editions, is dedicated to the Council and members. Mr. F. G. Parsons, so well known to us all and for many years an active member of the Club, died on February 7th, 1921.

In February Mr. Albert D. Michael, a past-President, was elected an Hon. Member.

The number of members on December 30th, 1920, was 495. During the year the attendance at Ordinary and Gossip Meetings has been materially improved, averaging 70 and 62 respectively. This is the more satisfactory in view of the restricted accommodation available, which is a matter of some anxiety to your Committee, and which they hope to be able to improve in the near future. The accessibility of Cabinet and Library is particularly under consideration.

A notable feature of the year has been the admission of women to membership, which thus brings the Club into line with other learned societies in this respect.

The papers read were as follows :

January 13*th*.—Notes on Continuity and Discontinuity in Nature as illustrated by Diatom Structure, Sir N. Yermoloff, K.C.B.

February 10*th*.—Presidential Address : The Seed Leaf of Grasses and Cotyledons generally, Dr. A. B. Rendle, M.A., F.R.S.

March 9*th*.—A Log and some Mycetozoa, Mr. A. E. Hilton.

April 13*th*.—Rocks and their Microscopic Structure, Mr. C. H. Caffyn.

May 11*th*.—The Microscopic Examination of Paper Fibres, Mr. S. R. Wycherley, F.R.M.S.

June 8*th*.—The Microscopical Structure of Lichens, Mr. R. Paulson, F.L.S., F.R.M.S.

October 12*th*.—Nature's Infinite Variety, Dr. J. Rudd Leeson, F.L.S., F.R.M.S.

November 9*th*.—Some Methods of Preparing Marine Specimens, Mr. F. Martin Duncan, F.Z.S., F.R.M.S.

December 14*th*.—Some Notes on Shore Collecting, Mr. B. S. Curwen.

December 14*th*.—Fluid Mounts and Mounting Algae, Mr. E. D. Evens.

Besides these, numerous exhibits of apparatus and specimens were made at the Ordinary Meetings, notices of which will be found in the Proceedings.

On behalf of the members, your Committee thanks the authors of these valuable communications. The number of short papers or notes has not been so great as usual ; this, it is thought, may be due in part to the increase of new members. Such short communications stimulate the work of the Club and are always welcomed when they deal with methods of investigation or interesting material, and are worthy of encouragement, especially in those cases where lengthy scientific papers would be out of the question.

The Librarian reports that during the year 1920 he has been in attendance on the first Saturday afternoon in each month, to arrange for the loan and return of books in the Club's Library. In previous years it was possible to make fifteen attendances for this purpose, but during 1920 the Library could only be used on eleven occasions. This circumstance, and the time needed to visit South Kensington, have naturally caused a certain decrease in the number of books borrowed. About eighty volumes have been loaned and exchanged, and this response shows that the kindness of the President, Dr. A. B. Rendle, in permitting the use of the new Herbarium for this purpose, is gratefully appreciated.

The removal to South Kensington rendered necessary certain alterations to the doors, fitting and supplying new keys, and other services, all very generously given by Mr. J. Offord.

The Librarian desires further to express his personal thanks to Mr. F. W. Woodman, who gave valued assistance in dusting and arranging the books during the last months of the year 1919, a task occupying several days.

The presentations to the Library include :

GRATICULES.
By Julius Rheinberg. (*Trans. Opt. Soc.*) *Presented by the Author.*

MICROSCOPY.
By Dr. E. J. Spitta (3rd edition). *Presented by the Publisher.*

AQUATIC MICROSCOPY.
By A. C. Stokes. *Presented by A. W. Sheppard.*

FURNITURE BEETLES.
By Chas. Gahan. *Presented by the Trustees of the British Museum.*

THE HOUSE FLY.
By E. E. Austen. *Presented by the Trustees of the British Museum.*

DIATOMS ON THE SKIN OF WHALES.
By A. G. Bennett. *Presented by E. M. Nelson.*

FRESHWATER ALGAE FROM TURKESTAN AND NORWAY.
By Karre Münster Strom. *Presented by the Author.*

The publications of the Ray Society, including *British Orthoptera*, by John Lucas, and *British Charophyta*, by Groves and Bullock-Webster, were received on subscription.

The following memoirs, reports and proceedings have been received :

Academy of Natural Science, Philadelphia.
American Microscopic Society.
British Association Reports.
Bergens Museum, Aarbok.
California University.
Essex Naturalist.
Geologists' Association.
Glasgow Naturalist.
Hull Scientists' and Field Naturalists' Society.
Illinois State Laboratory Natural History.
Indian Museum, Calcutta.
Missouri Botanical Gardens.
Northumberland and Durham Natural History Society.
Notarisia.
Nyt Magazine.
Philippine Journal of Science.
Philadelphia Wagner Institute.
Photographic Journal.
Photomicrographic Society.
Quarterly Journal of Microscopical Science.
Royal Microscopical Society Journal.
Royal Dublin Society.
Royal Society of London.
Royal Society of New South Wales.
Smithsonian Institute.
South London Natural History Society.
Tijdschrift.
United States National Museum.
Victorian Naturalist.

In conclusion, the Librarian will be glad to welcome the newer members of the Club to the privileges of the Library, and is confident that when the advantages it offers in the way of valuable books of reference are known, they will not fail to use it regularly and often.

The Curator reports that during the past twelve months fifty-one slides have been presented by members.

Although no better accommodation than standing space has yet been found for the slide Cabinet, a concession on the part of the landlord has rendered it possible to make the slides available to borrowers to a limited extent; and the Botanical and Williams Collections, together with the various botanical, physiological and petrological descriptive sets, can now be borrowed on Gossip nights.

The revision of the various collections that has been in progress during the past three years is now practically completed, and important alterations have been made in the arrangement of certain sections, with a view to facilitating reference and future extensions.

The manuscript for the proposed new catalogue is completed, but, in view of the excessive charges for printing now ruling, the Committee does not feel warranted in incurring the expense of putting it in the printer's hands at present. A manuscript catalogue is being prepared for all groups, so that when adequate space can be secured for the Cabinets, the whole collections may again be available to borrowers.

The Committee again thanks Mr. Bestow for assistance rendered to the Curator in handling the slides, and also Mr. Newmarsh for help in repairing defective preparations.

The Secretary of the Excursions Committee, in submitting the report for the past session, is pleased to say that the programme, as arranged, was duly carried out. The attendance at the various excursions was fairly satisfactory, although the "finds" in general were not out of the usual.

During the session twelve meetings were held, and the average attendance was 22·6, being an increase on last year, but still under the record, which is 23·0 for the year 1914.

The first excursion was held on April 10th, when the Royal Botanic Society's Gardens, Regent's Park, were visited. The day was cold and wet, and the attendance was smaller than usual, only thirty-three being present. The "finds" were not so good, owing to the clearing of the larger vegetation from the lake, only two specimens of polyzoa were found, while hydra and volvox were conspicuous by their absence.

The next excursion was on April 24th, Loughton and Chingford being visited; at Strawberry Hill Ponds many good catches were made and over fifty different species of Desmids were identified, including *Roya obtusa.*

On May 8th, after an interval of thirty-five years, Mitcham Common was visited by the Club, and those who took part in the excursion were amply repaid with the abundance of their "finds"—Stephanoceros, Floscularia, Melicerta, Limnias and many free-swimming rotifers, including *Collotheca trifidlobata* and the male *Collotheca cornuta.* Many Desmids and the curious and elusive *Hydrodictyon reticulatum* were collected.

The next excursion was on May 29th to Greenford and Hanwell, where the party expected to find Lophopus, as it was very abundant last year, but not a single specimen was taken, although some sticks on which there were many clumps last year were fished up.

On June 12th a party of twenty-three visited Northwood and Ruislip. With the exception of *Pedalion mirum* nothing unusual was found. It may be recorded that at 4 p.m., when the members were returning through the wood, a thunderstorm of exceptional severity came on, and the downpour of rain continued for more than an hour. When the party reached the cottage where they usually have tea, they found the house crowded out with other excursionists who had also been caught in the storm, and they had to partake of tea in the garden, under the shelter of a tarpaulin.

On June 26th Richmond Park was visited, when many good "finds" were made, including *Pedalion mirum* and *Conochilus unicornis*, and many species of Desmids. On the kind invitation of Sydney V. Klein, Esq., F.L.S., the party called at Lancaster Lodge, Kew Gardens, and were entertained to tea by Mr. and Mrs. Klein. Mr. Klein, unable to take part in the excursion, had arranged a number of specimens for exhibition and supplied the members with Hydrodictyon, which he found in abundance in the lake in Kew Gardens.

On July 10th, by special permission, the Club visited the reservoirs of the Metropolitan Water Board, at Ferry Lane, Walthamstow, but the finds on this occasion were not so numerous as when the Club last visited them in pre-war days.

Only ten members took part in the excursion on July 24th to Snaresbrook and Higham's Park Lake, but these were rewarded in finding the polyzoa Paludicella and Fredericella.

The next excursion, on August 14th, was to Hayes and Keston Common, places which had not been visited by the Club for fifteen years. Twenty-four members were present, and specimens of *Drosera rotundifolia* and Chara were collected and the rather rare rotifer *Elosa worrallii.*

On August 28th, by the special permission of the Port of London Authority, Surrey Commercial Docks were visited, and amongst other interesting things we took Cristatella and young sponges in great profusion. The thanks of the Club were awarded to the Authority and their representative, Mr. Grindell, who very kindly acted as guide to the party.

On September 11th Totteridge was again visited, and on September 25th the last excursion of the session was held to Hampton Court, when several species of rotifers and polyzoa were collected. On the kind invitation of Dr. Leeson, the party called at Clifden House, Twickenham, and were entertained to tea by Dr. and Mrs. Leeson. This is the third occasion on which the party were so entertained by the Doctor, who, as on former occasions, showed them many strange and curious specimens from his interesting collection.

The Committee regret that, owing to the heavy expense of printing and particularly the production of plates and illustrations, it has been found necessary to reduce the issue of the *Journal* to one number a year. This is felt to be a serious restriction of the usefulness of the Club, particularly to distant members. In this connection it is greatly to be regretted that further difficulty is caused by arrears in payment of subscriptions, not to mention the heavy task imposed on the Treasurer and extra expense in collecting the overdue amounts. It is sincerely hoped that this difficulty only needs mention to members in order to remove it.

The Committee again thanks, on behalf of the members, the various officers who have so readily and efficiently carried on the work of the Club, the continued vigour of which is due to their energy.

The Hon. Secretary greatly regrets that he has found it necessary to ask the Committee to accept his resignation owing to the increasing pressure of work. He feels confident, however, in handing over the office to a successor who readily volunteered, that in his able and experienced hands the Club will not fail to benefit and continue to prosper.

In conclusion, the Committee looks forward confidently to the future, in view of the promising activity and interest of the members during the past year, and hopes that a way will soon be found to gather again the whole of the Club's property under a single roof, with a prospect of greater accessibility and increased utility to the members.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

For the year ending December 31st, 1920.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance from 1919	56	8	4	By Rent	60	7	6
,, Subscriptions	242	0	0	,, Expenses of *Journal*	57	6	6
,, Dividends	13	17	0	,, Postages, etc.	3	17	6
,, Sales of *Journal*	15	10	11	,, Printing and Stationery	19	3	2
,, Contributions to Cost of Plates, Messrs. Paulson, Soar and Williamson	10	0	0	,, Attendant	1	11	1
,, Advertisements	10	15	0	,, Petty Expenses	2	1	3
,, Donation, Sir B. H. Jones	5	0	0	,, Books and Slides	14	18	6
				,, *English Mechanic*	10	3	6
				,, Balance in hand	184	2	3
	£353	11	3		£353	11	3

INVESTMENTS.

	£	s.	d.
$2\frac{1}{2}$ per cent. Consols	334	1	6
Metropolitan Water Board Stock	100	0	0
Metropolitan Stock	100	0	0
$2\frac{1}{2}$ per cent. Annuities, 1905	100	0	0

We have examined the above Statement of Income and Expenditure and compared the same with the vouchers in the possession of the Treasurer and have verified the Investments at the Bank of England.

JAMES C. MYLES }
J. WILSON } *Auditors.*

FREDK. J. PERKS, *Treasurer.*

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the 554th Ordinary Meeting of the Club, held on October 12th, 1920, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on June 8th were read and confirmed.

Mrs. A. C. Clarke, Messrs. Frederick Addey, B.Sc., G. Oldfield Allen, Arthur Curwen and Richard S. Bagnall, F.R.S.E., F.L.S., were balloted for and duly elected members of the Club. Eight nominations were read for the first time.

The thanks of the meeting was accorded to Mr. Bell, of Melbourne, Mr. D. E. Williams, of Australia, and Messrs. Gillespie and C. J. Sidwell for their contributions of slides to the Club Cabinet. The meeting received with regret the announcement by the President of the death of Mr. Wynne E. Baxter, who had been a member of the Club for nearly thirty years. He was born in 1844, and served for many years as coroner for East London; he was the first mayor of Lewes, 1881–2, and will be known to the members as the translator of Van Heurck's *Treatise on the Diatomaceae* and *The Microscope: Its Construction and Management.*

Mr. Addey then exhibited a scale for measuring directly the actual size of objects in microscopical drawings or photographs made to any known magnification. Mr. Edgar exhibited a home-made modification of Baker's nature microscope, the various movements being so constructed that rough usage would not be likely to spoil them. Mr. Traviss exhibited a simple but very effective cover-glass cleaner consisting of a flat block of wood with a flap of American cloth glued on to one side, so that it can be wrapped over the flat surface. Cover-glasses when placed on the American cloth may be rubbed hard with a cloth without risk of moving or breaking them, and when clean can easily be removed from the loose flap of material.

The President then called on Dr. J. Rudd Leeson to read his paper on "Nature's Infinite Variety." It is impossible to do more than summarise very briefly the chief of the many points touched upon by Dr. Leeson in dealing with this vast subject. Of the causes of Nature's infinite variety, he said, we know nothing, He proposed to limit himself to the consideration of the animal kingdom alone, and see if it were possible to attempt any explanation of it at all. The outside world, said the speaker, dawns upon us very gradually, and it is not until we begin to study and observe it carefully that we realise its complexity; and even then the more we learn, the more we realise the extent of our ignorance. The complexity is bewildering. After we have enumerated the known species of living things, we find that no two individuals of the same species are alike, and we may even go so far as to say that no leaf is the exact counterpart of any other leaf that ever has been or ever will be. The question cannot be solved by unintelligible metaphysical jargon; we must have recourse to the scalpel and the microscope, and then seek an explanation from the chemist and the physicist. We do not even know what a species is; attempts are made at definition, but with increase of knowledge definitions become obsolete. We have travelled a long way since Darwin read his world-awakening paper on July 1st, 1858, but all the time, said Dr. Leeson, we have been going back to the standpoint of the early Greek philosophers—the physical view of life; and it was reserved for Herbert Spencer to gather up the threads of modern science in his immortal *System of Synthetic Philosophy*. Man being a cause-seeking animal, and not knowing how species arose, guessed at the explanation. The first guess was the "special creation hypothesis," followed by Aristotle's "Entelechy," postulating "an indwelling cause giving form." Many other philosophers speculated on the subject, but Treviranus in 1802 first elaborated a theory of evolution. Lamarck thought he saw in "Use and Disuse" the solution of the mystery. Malthus suggested a struggle for food as the real cause, and Darwin believed the power of Hunger and Love to favour the survival of the fittest. The power of environment as a moulding and altering cause is still the fashionable idea, but it turns out to be only a series of sieves, a weeding-out process, and has nothing to do with originating specific variations. Dr. Leeson then proceeded to trace the gradual realisation of organic structure, beginning with Galen, Vesalius and the Arabians. The microscope was discovered by Galileo in 1610, and a little later Harvey discovered the circulation of the blood, and Hooke figured a section of cork "divided into little boxes or cells." In 1677 Leeuwenhoek discovered spermatozoa, but it was not till 1827 that Baer first saw the mammalian ovum. In 1801 Bichat showed the body of one of the higher animals to be a collection not only of organs, but of tissues, and cellular structure was announced by Schleiden and Schwann in 1839. In 1870–5 we knew only the nucleus and nucleolus, and the lecturer remembered Dallinger demonstrating the chromatin threads of the nucleus in 1886. All this was very wonderful, but it only pushed the mystery farther back. Dr. Leeson then went on to explain the miracle of miracles: how that we all spring from the union of two cells through which are transmitted the form and characteristics of our parents. In 1880 Weismann discovered that the germ-plasm is differentiated from the body-plasm at a very early stage of development. The germ cells, if they get a chance of suitable union, never decay. They are like one-celled animals, which, unlike multicellular animals, never really die. The individual is merely the guardian of the race, the casket in which the reproductive cells are protected and matured. The immortal germ-plasm is the source of the life stream. The lecturer then described the differentiation of the germ-plasm into male and female elements and the necessity for the extrusion of the polar bodies from the ovum before union with a sperm cell can take place. Surface tension may be a factor in determining the contents of the polar bodies, but it is a matter about which we know little. We resemble our ancestors because we spring from the same germ-plasm, but we cannot tell what characteristics we lose through the polar bodies. Bateson thinks that evolution may be largely a question of loss and favourable unpacking. The fertilised ovum divides into thousands of cells which soon differentiate, and the fate of children and grandchildren is settled by the separation of certain cells which form the reproductive tissues. These are the most important part of the creature, and the other cells serve them. Environment does not alter the structure of the germ cells. It may and does cause variation in unicellular animals in which there is no segregation of the germ cells; but as no rearrangement of the already constructed germ-plasm is possible, so no personally acquired characteristics are inherited. The chromosomes are the essential part of the cell, and so chromatin is the physical basis of life.

Here we reach the limits of microscopical science, and the further investigations are in the hands of the chemist and physicist. Protoplasm is the most complex substance known; twenty-nine of the eighty-two known elements occur in it. Here Dr. Leeson explained the chemical composition of protoplasm and the grouping of the atoms. "Life is a function of the interaction of these atoms." The immense possibilities of variation owing to the formation of *stereo-isomers* (substances having the same chemical composition but with the atoms differently arranged) was then dealt with, and the lecturer passed on to the structure of the atoms themselves. "Just think," he said, "of the material Nature has to work with, and marvel no more at her infinite variety." As atoms may be differently arranged, so electrons may be differently arranged in the atom, and we have an endless possibility of variation, and we marvel not at the variety of Nature, but at Nature's restraint.

After a few remarks by the President, the meeting closed with a hearty vote of thanks to Dr. Leeson for his interesting paper.

At the 555th Ordinary Meeting of the Club, held on November 9th, 1920, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on October 12th were read and confirmed.

Mrs. Mary Fletcher, Mrs. Emilia Frances Noel, Mrs. Gertrude Addey, Messrs. Henry Hubert Harris, Ernest Erant, Thornton Knowles, Wilfred Eldridge Watson and Cyril Dickinson were balloted for and duly elected members of the Club. Nine nominations were read for the first time.

The Hon. Secretary announced that a pamphlet from the Mosquito Investigation Committee of the South-Eastern Union of Scientific Societies had been received. (The pamphlet contains notes on the life-history, distribution, etc., of *Anopheles plumbeus*, and appeals for help in obtaining further information.) Copies of the British Museum (Natural History Section) pamphlets on "Furniture Beetles" and the "House Fly" had also been received. The Hon. Secretary read a note from Mr. Woods recommending that in the case of mounts in media containing glycerine a ring of cement should be put on the cover-glass as well as on the slip, as good contact is obtained more easily than by ringing the slip only. Mr. J. Wilson exhibited some specimens of *Hydrodictyon africanum* from near Cape Town, and Miss Stevens, who had collected the material, gave a brief description of its occurrence in great quantities in ponds which during the dry season dried up.

The President then called upon Mr. F. Martin Duncan to read his paper on "Some Methods of Preparing Marine Specimens."

A very hearty vote of thanks was accorded to Mr. Martin Duncan for his very helpful paper.

At the 556th Ordinary Meeting of the Club, held on December 14th, 1920, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on November 9th were read and confirmed.

Mrs. Caroline Winifred Leeson, Miss Mary Hutton Brooks, Miss Agnes Jane Gamman, Messrs. Williams Henry Weightman, Frank Garland, Edmund Maurice, Harold Tinson, Harold A. Moncrieff and Frank Ernest Liechti were balloted for and duly elected members of the Club. Six nominations were read for the first time.

The Hon. Secretary announced that Mr. E. M. Nelson had presented a copy of A. G. Bennett's paper on "Diatoms on the Skin of Whales"; "Freshwater Algae from Caucasus and Turkestan, Tuddal, and Telemark (Norway)," by K. M. Strom, had been presented by the author.

Sir Nicolas Yermoloff exhibited some balls formed of the fibres of a marine plant, *Posidonia caulini*, felted together by the action of the waves and thrown up on the beach at Cannes. The President showed some similar balls which he had found on the shore at Adelaide in great quantities. Dr. Rendle explained that the leaves of *Posidonia* are long and ribbon-like and strengthened by strong fibres. When the leaves decay these fibres are worked up into balls by the sea movements, generally round a bit of stem as a nucleus. The species from Australia was *Posidonia australis*. The President said that the balls were analogous to the fibrous balls frequently found in the stomachs of ruminants.

Mr. B. S. Curwen was then called upon to read his paper, "Notes on a Few Days' Shore Collecting in the Vicinity of the Needles, Isle of Wight." Mr. Curwen was fortunate in having been able to collect at Hastings and Bexhill in June, the South Cornish coast near Falmouth in July, and Totland and Freshwater Bays, Isle of Wight, at the end of August. He began by giving a brief survey of the relative frequency of the various groups of marine organisms at these places. Marine algae and sea-anemones were most plentiful on the Cornish coast, while hydroids were best represented at Hastings. There were plenty of the encrusting forms of Polyzoa at both Falmouth and the Isle of Wight, but the branching forms were far more plentiful at Totland Bay than anywhere else. For Porifera, Echinodermata and Crustacea the Cornish coast ranks highest. The collecting at the Isle of Wight was done at three low spring tides, one each at Totland, Colwell and Freshwater Bays. While waiting for the first low tide, the Headon beds, which come down to the beach at Totland Bay, were examined, and fossil fruits of several species of Chara were found in profusion, besides seeds of Potamogeton and water-lily. The marine algae appear to be fairly typical South-coast species. *Padina pavonia* grows profusely and covers large areas in sandy parts at about half-tide mark. Hydroids were not very plentiful, although two species not included in the list given in *The Natural History of the Isle of Wight*, edited by Morey, were among the eleven taken. Zoantharia were plentiful, the most interesting being the colonial form *Polythoa arenacea*. Mr. Curwen counted twenty in a row, about two feet long, with their tentacles projecting slightly above the sand. On touching the first one of the row, which promptly contracted, it was interesting to note the communication of the agitation along the whole line, one closing after another in regular sequence. About twenty species of Polyzoa were recorded, three being new to the Isle of Wight list. A profusion of the encrusting forms occurred on the Laminaria. An interesting point noted was the association of a Bugula (apparently *B. flabellata*) and an encrusting species, *Mucronella coccinea*. In practically every case the Bugula growing on Laminaria fronds was surrounded at its base by a more or less circular patch of the Mucronella. The fine condition of both species might indicate the relationship to be symbiotic. Two species of Pycnogonids were found, many specimens sheltering at the roots of Laminaria in company with *Ophiocoma neglecta* and a minute crab. Two species of spectre shrimps new to the Island list, *Caprella tuberculata* and *C. linearis*, were found, and a sea squirt, which, when mounted, showed the extrusion of one of the young Ascidian tadpole-like larvae. The number of new records in a short visit is no reflection on the published local lists, but indicates the large field open to the collector of marine biological material.

After a few remarks by the Hon. Secretary and Mr. J. Milton Offord, a hearty vote of thanks was accorded to Mr. Curwen.

The President called upon the Hon. Secretary to read two papers by Mr. E. D. Evens on (1) " Fluid Mounting " and (2) " Mounting Freshwater Algae, Mosses, etc."

A very hearty vote of thanks was accorded to Mr. Evens.

At the 557th Ordinary Meeting of the Club, held on January 11th, 1921, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on December 14th, 1921, were read and confirmed.

Mrs. Bertha Mary Curwen, Mrs. Eva Curwen, Mrs. Muriel Anne Fryer, Messrs. Henry Charles Shaw, Edward Ebden Jones and Reginald Hunt were balloted for and duly elected members of the Club; and as Hon. Member, Dr. E. J. Spitta, L.R.C.P., M.R.C.S. Three nominations were read for the first time.

The President announced the death of Mr. T. A. O'Donohoe, I.S.O., and the news was received with much regret by the members. Mr. O'Donohoe was an old member, and well known as a very skilful microscopist and photographer; he was a very regular exhibitor at the meetings until the last few years, when ill-health often prevented him from coming. A letter had been received from Dr. E. J. Spitta's daughter tendering her father's resignation from the membership of the Club owing to the weak state of his health. In view of Dr. Spitta's services to the Club and to microscopy, the committee recommended that he should be elected an honorary member of the Club. This proposal was unanimously approved by the meeting.

The President then read the committee's nomination of officers for the ensuing year, and nominations were made by the meeting to fill the vacancies caused by the retirement of the four senior members of the committee. The election will take place at the Annual General Meeting on February 8th.

Messrs. W. Watson & Sons, Ltd., exhibited two microscope mirrors made of stainless steel, and a pamphlet on photomicrography issued by a firm of photographic plate makers. The mirrors, one plane and the other concave, give beautiful images, and seem likely to be very satisfactory if it is possible to prevent the surfaces from becoming tarnished or damaged during use.

Mr. J. T. Holder exhibited a series of lantern slides made from his own preparations showing the structure of the cornea. These were followed by several photographs taken by reflected light of the heads of various insects and a spider.

Dr. Rendle exhibited the inflorescence of an arum lily having a second spathe or bract above the normal one. This second bract was beginning to split, apparently indicating an attempt to form a third spathe.

The President then called upon Canon Bullock-Webster to give his address on the Charophyta. These plants, said the Canon, belong to a singularly unknown department of botany. It has been found impossible to include them in any of the four great divisions of the vegetable kingdom, and this small family of obscure and lowly plants has accordingly been raised to the dignity of a distinct division. The group is divided into two families, Nitelleae and Chareae, which are distinguished the one from the other by the coronula, a small group of cells which crowns the oogonium. In Nitelleae the coronula is double-tiered, consisting of five cells, each one having another cell growing from its distal extremity. The coronula of Chareae consists of five single cells. The family Nitelleae is divided into two genera, Nitella and Tolypella, there being ten and four British species of each respectively. The Chareae are divided into four genera, Chara, Nitellopsis, Lychnothamnus, and Lamprothamnus. There are sixteen British species of Chara, one of the second, and one of the fourth, the third genus being unrepresented. The total number of British Charophyta is at present thirty-two, and of European species fifty-four. The total number of species probably does not exceed two hundred, and the last three genera are very rare. The commonest Nitella in England is *N. opaca* ; it is dioecious, and has simple bifurcated branches. Charophytes may always be distinguished by their reproductive organs consisting of antheridium and oogonium. The fruit consists of an oospore surrounded by a gelatinous transparent envelope of five cells, which form a series of spirals round it. These enveloping cells eventually disappear and leave a series of spiral ridges on the oospore, often flanged. The stems and branchlets of the Nitelleae have single cells, while the Chareae have a series of cortical cells surrounding the central cells. *N. capillaris* is a very rare species, only found in one ditch in England. Its fruit is entirely surrounded by a transparent gelatinous substance. Several other species are very rare, but there seems to be no fear that collectors may exterminate them, as it is impossible to drive out a charophyte that is determined to stay, and equally impossible to keep one that is determined to go. It is often very difficult to determine the species of a charophyte, and microscopic characteristics have to be relied upon. The mucro which terminates the branchlet is sometimes of specific value. *N. batrachosperma* and *N. tenuissima* are so much alike that it is almost impossible to distinguish them without a microscopical examination, a point of difference being the decorations which are found on the membrane of the oospore. The most interesting Nitellas are found in freshwater near the sea, which is always a likely place in which to find them. The growth of the cortical cells of the Chareae proceeds from the nodes of the stems and branchlets, and they grow upwards and downwards along the stem until they meet in the middle. A very curious appearance is produced in *C. denudata* by the cortical cells being remarkably undeveloped, and not reaching those which have started to meet them. On the other hand, an Irish species of Chara has very large cortical cells and large spine cells. *C. fragifera*, which is found only at Land's End and the Lizard, has very well-developed cortical cells and starch bulbils on the roots. *C. aspera* has single spine cells, while *C. desmacantha* has strongly developed fasciculated spine cells. The fruits of the charophytes are filled with starch and fat granules. When growth begins the cells divide, forming the proembryo and the root; the proembryo has a node from which the sexual plant starts; accessory embryos also develop. The antheridium is one of the most beautiful structures in the botanical world. It consists of eight shields closely adpressed together. From the middle of each a sort of handle, called the manubrium, projects inwards, and at the end of this is a bunch of filaments. Each filament consists of 100 to 200 cells, each of which contains an antherozoid. When the antheridia are ripe the water must be swarming with the antherozoids which are set free. The antheridia are an orange colour, and are enclosed in a transparent envelope. When the time comes for fertilisation the enveloping cells of the oogonium separate at the top and leave an opening by which the antherozoids enter, or sometimes the neck elongates, and they enter at the side, just below the coronula. Large numbers of the fossilised fruits of Charophytes are found in the secondary and tertiary beds. The oogonium is preserved owing to its secretion of lime, so that it becomes what is known as "lime shelled." This happens only in the case of Chara; Nitella does not secrete lime. The cells of the coronula do not secrete lime, neither does the basal cell; there is, therefore, always an aperture at the base of the fossil oogonium. The plant itself also secretes lime, but only on the outside, while the fruit secretes it within its enveloping cells so that the oospore becomes encased in a hard shell. Charophytes never come to the surface of the water in which they grow. They are to be found in pools, lakes, and especially fen ditches; recently dug-out clay-pits always contain them in two or three years. They cannot stand against stronger vegetation, and the secretion of lime may be an attempt to strengthen their weak stems. The apparatus suitable for collecting charophytes is a vasculum as airtight as possible, and plenty of newspaper or old handkerchiefs, a drag, and a hoe, preferably having an extension piece so that the handle may be lengthened. It is always necessary to do a great deal of wading, and there is nothing like the hand for getting specimens. If it is possible, work down to the bottom and grasp the wiry root, then wash the plant and wrap it in paper or cloth. By this means good specimens may be obtained, whereas it is almost impossible to obtain satisfactory ones by grasping the branches. The plants will bear no exposure to the air—after twenty-four hours' exposure little remains but a crumbly heap of lime. When drying, very strong pressure should be applied, so that the plant may be pressed into the paper. The speaker had specimens one hundred years old perfectly preserved in this way. The lecture was illustrated by lantern slides, and micro-slides were exhibited under several microscopes.

Dr. J. R. Leeson drew attention to the reversed spiral of the enveloping cells of some of the fossil specimens of oogonia;

a peculiarity that is not known to occur in any recent charophytes. After some remarks by the President and Messrs. Scourfield and N. E. Brown, the meeting closed with a very hearty vote of thanks to Canon Bullock-Webster for his very interesting address.

At the 558th Ordinary Meeting, being also the 55th Annual General Meeting of the Club, held on February 8th, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on January 11th were read and confirmed.

Messrs. Leonard Henry Tinson, Cecil Charles Swatman and Robert Pease were balloted for and duly elected members of the Club. Two nominations were read for the first time.

The Hon. Secretary announced that Mr. Woodman had presented Bauermann's *Descriptive Mineralogy* to the Club Library, and that Mr. W. J. Ireland had presented Bell's *Chemistry of Foods*.

It had been arranged for a series of exhibitions of new apparatus, etc., to be made by various opticians at the Gossip Meetings; Messrs. Beck would give an exhibition at the next Gossip Meeting on February 22nd. The news of the death of Dr. E. J. Spitta, which was announced by the President, was received with much regret, and the Hon. Secretary was instructed to send letters of condolence to his family from both the committee and the meeting. It was agreed that, as there had only been sufficient nominations to fill the various offices and the vacancies on the committee, the election by ballot should be dispensed with, and the President thereupon read the list of the officers and committee for the current year. The Hon. Secretary was then called upon to read the 55th Annual Report. The progress of the Club had been satisfactory; fifty-six new members had been elected during the year, a number only exceeded in 1906, when it was fifty-seven. Twenty-six members had been lost by death and resignation. The attendance averaged seventy at the Ordinary and sixty-two at the Gossip Meetings. During the year the Club had admitted women to its membership, and so fallen into line with most of the scientific societies. Dr. Rendle's kindness in arranging for the housing of the Library had been appreciated and good use made of the books. It had also been arranged for the Club Cabinet to be available to borrowers to a limited extent. A new manuscript catalogue had been prepared, but owing to the expense of production the committee did not feel justified in putting it into the printer's hands at present. The committee greatly regretted that it had been necessary to reduce the issue of the *Journal* to one number a year. The trouble to the Treasurer and expense to the Club caused by the number of overdue subscriptions was also a matter of some concern to the committee, and they trusted that, having mentioned it, those responsible would apply the obvious remedy. The new Hon. Secretary was very heartily welcomed, and the committee hoped that the Club's property might soon be gathered under one roof, with the prospect of increased utility in the future. The Treasurer (Mr. F. J. Perks) then read his balance sheet, which showed that the financial position of the Club was satisfactory. Mr. Perks drew the attention of the members to an entry in the balance sheet which formed a welcome innovation—viz. a gift of £5 from Sir B. H. Jones. The sum of £10 from contributors for expenses of the *Journal* had also been received. The report and balance-sheet were adopted, and Mr. Wilson drew attention to the fact that this was Mr. Perks's fourteenth year of office. The members expressed their appreciation of Mr. Perks's long and valuable services to the Club.

The President then asked Mr. D. J. Scourfield to take the chair while he delivered his annual address. Dr. Rendle took as his subject the part played by certain microscopic plants in the nutrition of the higher plants. Plant nutrition falls under two headings—the assimilation of (1) carbon, and (2) nitrogen. In the first case the CO_2 from the air finds its way into the tissues of the leaf, water is absorbed by the roots and by the action of sunlight on the chlorophyll, a carbohydrate is formed from the CO_2 and H_2O, which is either used at once or stored, generally in a solid form, such as starch. Protoplasm is a much more complex substance than the carbohydrates. It breaks up into complex nitrogenous substances, proteins, and in procuring the nitrogen for building up these proteins, and ultimately the protoplasm, from the carbohydrates, the microscopic organisms play an important part. The ultimate source of nitrogen is the atmosphere, but most plants are incapable of availing themselves of this supply. Certain bacteria, and perhaps also certain fungi, have the power of using this gaseous nitrogen as food. Some of these nitrogen-fixing bacteria are independent organisms living in soil or water—e.g. species of *Azotobacter*. These bacteria do not derive their nitrogen from organic substances, but can use free nitrogen. A second class of nitrogen-fixing organisms lives in the tissues of the higher plants. The most familiar is a small bacterium, *Pseudomonas radicicola*, which forms the well-known swellings on the roots of leguminous plants. This bacterium, which already exists in the soil, attacks the seedling plant by penetrating the thin wall of a root-hair. It acts, in fact, as a parasite, and multiplies rapidly. The bacteria form a filamentous zoogloea closely resembling a fungus hypha. The infected tissue grows vigorously, and a nodule is formed containing a central mass of parenchyma filled with bacteria surrounded by vascular bundles connecting with those of the root and enclosed by the cortex and epidermis. The parasite phase resolves itself into a condition of symbiosis, the bacteria obtaining their carbon from the sugar stored by the green plant in its root, and also causing the nitrogen and oxygen of the air to combine. Some of the bacteria are digested by the plant protoplasm, which thus obtains a supply of nitrogen. When the plant dies the nodules decay and the bacteria remain in the soil to carry on their work. This explains why a crop of leguminous plants leaves the soil richer in nitrogen than it found it. Similar nodules containing bacteria or fungus hyphae are found in other families. Green plants can ordinarily only derive their nitrogen from inorganic compounds, such as compounds of ammonia or nitrates, which are present in ordinary soils. Apart from the small amount of oxides of nitrogen formed during thunderstorms, these substances are products of the decay of organic matter in the humus, which is broken down by bacteria into simpler substances, among which is ammonia. Some plants can use ammonia compounds as a source of nitrogenous food, but generally they are first converted into nitrates. A bacterium, *Nitrosomonas*, generally present in fertile soils, converts NH_3 into HNO_2, which forms nitrites with the bases in the soil. Another bacterium, *Nitrobacter*, converts the HNO_2 into HNO_3, which similarly forms nitrates. These oxidations will only go on when the soil is properly aerated. Aeration of the soil also checks the action of denitrifying bacteria, which are always present when organic decomposition is taking place. These bacteria use nitrates and ammonia as food, and the nitrogen escapes as free gas. A few flowering plants, such as the bird's-nest orchid, are entirely dependent on dead organic material for their food. They grow under trees in soil rich in humus, and their roots are invested with a web of fungus hyphae, *Mycorhiza*, which invades the root tissues. The fungus utilises the carbonaceous and nitrogenous compounds in the soil, and the cells of the host plant derive nourishment by digesting the fungus. Some plants, such as the orchids and Ericaceae, are partial saprophytes, and have a mycorhiza, although they are apparently autotrophic. The germination of many orchid seeds is impossible unless the seedling is infected by the fungus. Sometimes the fungus is specific to the orchid, and sometimes the same fungus is capable of successfully inoculating various species. In some cells the fungus grows vigorously, while in others it is digested, thus passing on to its host the nourishment derived from the humus. There is no evidence that the fungus can fix the nitrogen of the air. Dr. M. C. Rayner has worked out the relationship between the common ling and the fungus which is associated with it. In this case infection does not depend on the presence of the fungus in the soil, but the hyphae permeate the whole plant and are associated with the seed in the fruit. The plant is in effect a phanerogamic lichen! Dr. Rayner succeeded in isolating the mycorhizal fungus from seeds and pieces of ovary tissue. The fungus thus obtained was used for the inoculation of sterile seedlings, which at once developed a root system and grew vigorously under aseptic conditions in closed tubes. A number of other Ericaceae were examined, and in every case mycelium could be identified in the ovary of the unopened flower. It was not found possible to replace the stimulus to development which follows seedling infection by supplies of various organic nitrogenous substances in the food material.

The address was illustrated by a series of diagrams, etc., projected on the screen, as well as by a number of micro-slides showing the fungal infection in roots; it was listened to with great attention, and a very hearty vote of thanks was accorded the President.

At the 559th Ordinary Meeting of the Club, held on March 8th, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on February 8th were read and confirmed.

Miss Caroline H. White and Mr. George Henry Sellar were balloted for and duly elected members of the Club. Seven nominations were read for the first time.

The Hon. Secretary announced that a copy of *Minerals and the Microscope*, by H. G. Smith, had been received from Mr. A. W. Sheppard, and three copies of a pamphlet on the "Diatomaceous Earth of Lompoc, California," by Sir Nicolas Yermoloff, from the author. The thanks of the meeting were accorded to the donors. It had been arranged for Messrs. W. Watson & Sons to give an exhibition in the Library at the next Gossip Meeting, on March 22nd.

The news of the death of Mr. F. A. Parsons was received by the meeting with much regret. Mr. Parsons had been a member of the Club for fifty years, and for fourteen years was secretary of the Excursions sub-committee.

The President drew the attention of the members to the statement by Professor Herdman, in his presidential address to the British Association at Cardiff, that the time was now ripe for another expedition for oceanographical exploration. The meeting passed a resolution expressing the interest and pleasure of the members in Professor Herdman's pronouncement, drawing the attention of the Government to the valuable work done in 1876 by H.M.S. *Challenger*, and urging upon them the desirability of making arrangements for another such expedition.

Dr. Tierney exhibited and described a portable microscope lamp. He had long felt the need for a really efficient and portable lamp, and it had been made in order to satisfy those conditions. The lamp packs into a small oval canister, is oil tight, has a half-inch flame, of which either the edge or flat can be used, and burns for three or four hours. The chimney is brass, and has a flat window consisting of a 3 in. by 1 in. slip. The lamp can be lowered for direct use or raised for use with the mirror, and it is very rigid. It was very much admired, and the thanks of the members were accorded to Dr. Tierney for bringing it before the Club.

The Hon. Secretary read a note by Mr. E. M. Nelson on Watson's stainless steel mirrors. Mr. Nelson had tested one carefully, and found it very satisfactory. By projecting sunlight on to the ceiling with the steel mirror and several ordinary glass mirrors, the steel mirror was found to lose a little light. He could not say anything about the keeping qualities of the mirrors, but he had two small ordinary steel mirrors about eighty years old which were still in good condition. Mr. Nelson then explained the double reflection which is obtained with an ordinary mirror. If the light is reflected at the polarising angle, the reflection from the glass surface is polarised, and can be extinguished with a nicol, while the image from the silver surface remains unaffected in either case. The thanks of the Club were accorded to Mr. Nelson for his note.

The President then called on Mr. S. C. Akehurst to read his paper on "The Larva of *Chaoborus crystallinus* (de Geer) [*Corethra plumicornis* F.]."

A hearty vote of thanks was accorded to Mr. Akehurst for his paper.

At the 560th Ordinary Meeting of the Club, held on April 12th, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on March 8th were read and confirmed.

Messrs. Thomas Henry Howells, Henry F. Sprinyer, Arthur George Morey Weale, Frederick Nathaniel Davidson, Albert Nelson Williamson and George Bagster were balloted for and duly elected members of the Club. Six nominations were read for the first time.

The Hon. Secretary read a list of the recent additions to the Library. The members expressed their appreciation of Messrs, Watson's exhibition and demonstration at the last Gossip Meeting, and the Secretary announced that Messrs. Baker would give an exhibition at the next Gossip Meeting on April 26th.

The President read an obituary notice by Mr. E. M. Nelson of Mr. G. E. Mainland, who died on December 22nd, 1920, at the age of eighty. He left London nineteen years ago, and so was not likely to be known to any but the older members of the Club, of which he was a member for many years. He was a keen microscopist and an excellent exhibitor. He discovered the diatoms of which Sozodont tooth powder is composed. The Secretary was directed to send a letter of condolence to Miss Mainland. Mr. Hilton said that he knew Mr. Mainland well. Owing to a nervous breakdown he went to the seaside, and his doctor suggested his taking a shilling pocket lens and spending his time on the shore examining anything he could find. He did so, and became an enthusiastic microscopist, although he had previously known nothing about it. Mr. Scourfield said that there was an interesting note of his on the polarising granules in Actinosphaerium.

Messrs. Watson very kindly sent a quantity of Oamaru earth for distribution, and a member brought a jar of " Palestine wine." The President said that this substance (which is also known as " Californian bees ") is the ginger-beer plant. It is a symbiotic association of a form of yeast and a bacterium, and may be fed on sugar, which it ferments.

Mr. A. A. C. Eliot Merlin then read a " Note on Photographs of *Nitzschia valida* and the Process of Auliscus." Two photo, graphs were exhibited and the method of taking them described. The objective used was a 1/12th in. apo. of N.A. 1·4, the condenser a P. and L. dry apo. at full aperture, and the illuminant the sun's disc reflected by a heliostat. A screen consisting of a solution of methyl green in glycerine and containing a piece of blue glass was used and a tank of water 8 in thick. Exposure, 20 seconds on Wratten "M" panchromatic plates. A specimen of *N. valida* was shown under the microscope. It is an excellent test for medium and high-power objectives, the transverse striae being 57,000 to 58,000 per inch, and the longitudinal 48,000 to 51,000. Thus the structure is well within the grasp of a lens of 0·65 N.A. Both photographs showed excellent contrast although, owing to their great transparency, both objects were difficult to photograph, especially with a large illuminating cone.

The Hon. Secretary read a note from Mr. Crowhurst, of Bromley, on a purple bacterium, a species of Lamprocystis. It forms large pink-violet, spongy masses, made up of thousands of bacterial cells united by their gelatinous walls. Mr. Crowhurst very kindly promised to send a supply of Lamprocystis at a later date. Mr. Scourfield said that Mr. Nelson had succeeded in demonstrating the flagellum of the bacterium. The thanks of the meeting were accorded to the foregoing donors and authors.

The President then called upon Mr. N. E. Brown to read his paper, " Notes on the Structure and Growth of Diatoms." A diatom, said Mr. Brown, is a microscopic aquatic plant having a transparent siliceous shell constructed on the plan of a pill-box. The structure of the valve may usually be classified as: (1) hexagonal structure; (2) small dot-like structure, or (3) linear markings difficult to resolve into dots, as in Pinnularia. Although these variations appear at first sight to be distinct types, Mr. Brown is disposed to regard them as modifications of one type. Broken pieces of valves are more useful for investigating structure than complete ones, because, where the shell has broken across the cells, the fractured edges of the membranes closing the cells can be clearly seen when properly focused, thus demonstrating decisively that the cells (or so-called dots) are not perforations or holes through the shell as they are commonly but erroneously supposed to be. The structure of *Coscinodiscus oculus iridis* was explained with the aid of lantern slides of a broken specimen and a section of Mors *Cementstein*, in which the diatom occurs. The valve was shown to consist of hexagonal cells closed by siliceous membranes at both ends. The partitions between the cells are thickened and slightly projecting at the outer surface, and the "eyespots" in the lower membrane are shown in the sections to be closed by a drum-like structure. When the focus upon a diatom having hexagonal cells is lowered below the upper surface, appearances of the side walls are seen that are considered to be only diffraction effects, but Mr. Brown thinks it possible that they may be very imperfect views of the structure of the cell walls blurred by diffraction. For upon examining the scar left on the inner wall of the valve by the breaking off of the partition walls, he finds it to be formed of contiguous dots, as if the walls were formed of rods of silex cemented together. Photographs of *C. asteromphalus* were shown next and the structure explained. The lecturer did not consider either the "white-dot" or the "black-dot" image to be the true focus. There has been much controversy concerning the nature of the so-called dots seen upon diatoms. After much careful examination, Mr. Brown has come to the conclusion that most, if not all, dots are cells similar to those of the *Coscinodisci*, but without an eyespot; and that they are not holes, but are covered by a membrane. *Isthmia enervis* and *Navicula lyra* were taken as examples and explained with the help of photographs and diagrams. The bead-like appearance which is often mentioned in books he ascribed to faulty illumination. In the case of *N. lyra* the true focus (for which Mr. Brown suggested the term "structure-focus") was to be found between the "white-dot" and "black-dot" images. The markings consisted of rectangular cells closed on both surfaces by a thin membrane, the outer membrane being sunk in a very shallow pit below the surface of the valve. The outer cell wall was found to be dotted. A similar structure, discovered by Mr. E. M. Nelson, was described as occurring in *Pleurosigma formosum.* Although formerly accepting the view that diatom valves were perforated, Mr. Brown is now of the opinion that there are no real holes in them, and that the entry of fluids into the valves may admit of another explanation. He thinks that a clue might be found in Professor Dendy's discovery of some siliceous sponge spicules that are capable of absorbing water, and suggested the possibility of the cell walls of the valve being formed of some such material. The growth of diatoms was then dealt with. Mr. Brown does not accept the theory that growth of a diatom does not take place. The theory that is generally held is that the frustule keeps on forming new and smaller valves until eventually conjugation between two frustules of the minimum size takes place and an auxospore is formed, which is an individual of the largest size that repeats the divisional process until the minimum stage is reached and conjugation again takes place. He finds evidence of growth difficult to obtain, although it exists. For instance, a colony of a Cocconeis was once seen consisting of diatoms of all sizes, and the lecturer felt convinced that the colony was derived either from invisible spores or from very young sporangial diatoms. Mr. Brown considers the auxospore to be merely a sporangium from which young diatoms are developed. Dr. Burton Brown made observations on *Encyonema prostratum.* He saw the diatoms conjugate and found that after the auxospores were developed a lot of young Encyonemas appeared which grew larger, while the outside tests of the auxospores remained where they were and gradually dissolved. The so-called auxospore condition of *Cymbella cistula* was then described and explained. The following is the method of reproduction as observed in *Cymbella cistula* by Mr. Brown and illustrated by specimens under the microscope: A single adult diatom surrounds itself with a gelatinous sheath and a small mass of protoplasm is extruded from between the valves on the ventral side. It is covered with a thin, structureless, siliceous membrane. An organised baby diatom replaces the structureless mass, and from this stage every condition up to seven or eight fully grown diatoms in the same cyst may be observed. The young ones move about until nearly fully grown, when they arrange themselves into a barrel-shaped mass and develop endochrome. Eventually the sheath disappears and the diatoms become free. Indications of growth, such as division of the cells, have been observed by Mr. Brown in mounted specimens, and a photograph of an Arachnoidiscus was shown in which such division could be seen, and the method by which new sections were added to the disc was described in detail.

A hearty vote of thanks was accorded to Mr. Brown for his paper. The Secretary announced that Mrs. O'Donohoe had presented to the Club a collection of her husband's photographs, and he was directed to send a letter of thanks to her for her kind gift.

At the 561st Ordinary Meeting of the Club, held on May 10th, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on April 12th were read and confirmed.

Mrs. D. C. Davies, Mrs. M. D. Edmunds, Messrs. Ernest Harold Newman Skrimshire, Sydney V. King, D. C. Davies, Frederick M. Jones and Arthur Edmunds, B.Sc., C.B., M.S., F.R.C.S., were balloted for and duly elected members of the Club. Two nominations were read for the first time.

The Hon. Secretary announced that ninety-seven pathological slides had been presented to the Club by Mr. Maurice, and that a copy of *Contributions to the Biology of the Danish Culicidae*, by C. Wesenberg-Lund, had been received from the author. The thanks of the Club were accorded to the donors.

The Hon. Secretary read a note from Mr. Nelson on "*Aulacodiscus Janischii* Gr. and St." Mr. Nelson has recently discovered the secondary structure of this diatom capping the primaries. The valve must be examined from the inside, as the structure is invisible from the outside. Mr. Merlin had confirmed the image, which he stated to be "very difficult and evasive." The structure was seen with a 1/12 in. apo., and illumination was obtained from the edge of the flame of a half-inch wick by a Holos condenser oiled on and working at full aperture. A peacock-green screen was used.

A letter from Mr. T. Midgley, of Bolton, was communicated to the Club by Mr. Carter, recommending the use of "Necoloidine" as a substitute for celloidin. Mr. Midgley had used this substance as an embedding medium for cutting sections of cotton and other fibres with complete success.

The Secretary announced that a quantity of deep-sea deposits had been received from Mr. Ham for distribution. He proposed to divide them up into packets and to distribute them to members interested in due course.

The President drew attention to the fact that the unwritten law that smoking should not be indulged in at the meetings had occasionally been violated, and that the committee's attention had been drawn to the matter. The committee had decided that the members should be asked to refrain from smoking at any of the meetings.

Mr. Merlin was then called upon to read his paper on "Black- and White-Dot Focus." Mr. Merlin thought it might be of interest if the minute secondary structure of *Pleurosigma formosum* which Mr. Brown had mentioned at the previous meeting as having been shown to him by Mr. Nelson, and with which he had long been familiar, could be photographed. He made the attempt, and submitted the resulting photograph to the meeting. The magnification was 4,000 diameters, the objective used an apo. 1/12 in., N.A. 1·4, illuminating cone N.A. 1·3, illuminant sunlight. The main structure was represented in dark-dot focus, the minute secondary perforations, usually about 4, being indicated by darker shading near the margins of the primaries. The diatom was mounted in styrax. The secondaries always appear black at a definite focus, and no "white-dot" effect can be obtained. Mr. Merlin considers them to be perforations in the capped structure of the primaries. Diffraction effects were reduced to a minimum owing to the very large illuminating cone employed. Mr. Merlin also showed two photographs of the secondary structure of *Triceratium* sp. showing the "white-dot" and "black-dot" effects. In the latter the framework of the diatom was sharp, while in the former it was out of focus. Mr. Merlin finds the black dots to be sharp and at the level of the convex upper surface of the valve framework, while the white dots are merely optical images formed by the structure at a level well above the valve surface. An examination of fractures under critical conditions confirmed Mr. Merlin's interpretation of the secondaries as perforations. Increasing the illuminating cone when the "white dots" are in focus causes them to disappear, while the same experiment with the black dots merely reduces the contrast and they remain in focus. Mr. Merlin said that most of the observational facts mentioned were due to Mr. Nelson; he claimed no originality for any of them.

Commander Ainslie said that he had arrived at the same conclusions as Mr. Merlin with regard to the black-dot image. He said that the use of the correct tube length tended to do away with false images, and that the correct image was the evanescent "black dot" with a wide cone of illumination and perfect tube-length adjustment. Mr. N. E. Brown did not agree that diatom valves were perforated. He thought that the black dot was the result of the effect of light on the thin convex or concave membrane with which he believed the "dots" to be covered. He did not believe it possible to get black- and white-dot images of a hole. When Mr. Nelson showed him the secondaries of *P. formosum* he had seen eight surrounding dots and more in the middle of the primary, which was sunk in a shallow depression. The thanks of the meeting were accorded to Mr. Merlin for his interesting communication.

Mr. Pledge was called upon to read his paper on "The Use of Light Filters in Microscopy." Mr. Pledge said that the earliest record of the use of a light filter in this connection was about 1704, when John Marshall made a microscope in which the eye lens was made of smoked glass to render the colour fringes formed by the simple objective less apparent. The matter appears to have received no further attention till 1837, when Brewster referred to the advantage of coloured screens for correcting chromatic aberration. Adams (1787) records the use of oiled paper or "glass lightly greyed" for modifying the intensity of sunlight or the yellow colour of artificial illuminants. The first application of light filtering applied to photomicrography was by Kingsley in 1860. He used a solution of aesculine with an oxyhydrogen light to absorb the ultra-violet, and so obtain sharper results. The use of polarising apparatus and coloured solutions and glasses was recommended by subsequent isolated workers, but it was not till after the introduction of orthochromatic plates in 1882 that light filters received serious attention as a method of controlling contrast in photomicrography. Sanger Shepherd & Co. put the first set of filters on the market in about 1900, and in 1904 described a set covering the whole range of the visible spectrum. The Wratten M filters were issued in 1907, a series by the Lifa Co. of Augsburg in 1917, a set for photomicrography by Ilford, Ltd., in 1919, and the Wratten visual M filters in 1920.

By the use of suitable filters the photographic rendering into monochrome of the colour contrasts of a preparation may be completely controlled. Resolution of fine structure may be made easier by blue filters, the definition of achromatic objectives may be improved by green, and the intensity of illumination modified by neutral tints. If a colour is to be rendered as black as possible it must be viewed or photographed by light which it completely absorbs, i.e. by light of the wave-lengths comprised within the dark parts of the spectrum obtained by viewing the colour with a spectroscope. A conventional spectrum of blue, green and red was then shown on the screen, and the extinction of the various colours demonstrated by the interposition of suitable screens. The position of the absorption bands is indicated either by reference to the Fraunhofer lines or by a statement of the wave-length of the light involved. In order to avoid blocking of detail it is advisable to use a screen whose transmission band is not centrally placed as regards the absorption band of the colour in the preparation. As contrast is increased by the use of a filter of the colour complementary to that of the preparation, so it may be reduced, if necessary, by using a screen of a similar colour. This latter condition frequently presents itself in the case of insect preparations that are too dark, and a red or yellow filter may be used in these cases to bring out the detail.

As regards the properties that should be possessed by a set of light filters for use in microscopy, they should be: (1) efficient, i.e. passing as high a percentage as possible of the light required; (2) convenient; (3) permanent, under reasonable conditions, and (4) there should be as few as possible consistent with affording complete control of contrast. Coloured glass filters do not fulfil the first condition, nor do they give clean-cut transmission bands, otherwise they would fulfil the conditions. Liquid filters are suitable for laboratory use, but, on the whole, nothing is so convenient or satisfactory as dyed gelatine films cemented between two glasses. For general use it is desirable to have a series of filters which will give, when used either singly or in combination, a successive series of narrow transmission bands through the visible spectrum. The Wratten M series and visual M series fulfil these conditions. For restricted work one or two filters may be all that is necessary. Mr. Pledge then dealt with the various methods of holding filters. The best place is as near the light source as convenient, but it may sometimes be convenient to put the filter over the eye-piece. In conclusion, Mr. Pledge described in detail some of the Wratten filters made by Kodak, Ltd., and showed a series of slides giving a good idea of their use. He also exhibited a large series of the filters themselves. The meeting expressed its appreciation of Mr. Pledge's paper by passing a very hearty vote of thanks.

Mr. Soar gave an address on "Microscopical Drawing." Mr. Soar said that he could add very little to what Mr. Suffolk had said to the Club fifty-two years ago. Drawing without auxiliary instruments is only possible to experienced artists, and it always has the disadvantage of affording no clue to the dimensions of the object. Mr. Suffolk believed that with the aid of a camera lucida or square ruling in the eye-piece anyone could make drawings that would be more truthful than those of a more skilful draughtsman made without such aid. In Martin's treatise on the microscope (1742) there is a description of a camera obscura used for drawing, the image being projected on to a sheet of paper in a darkened chamber by the sun's rays. In Henry Baker's book on the microscope (1753) is a description of the employment of a squared micrometer in the eye-piece made of fine wire, the drawing being made on squared paper. Dr. Wollaston's camera lucida was introduced at the beginning of the last century, and since then all sorts of different kinds have been made. Mr. Soar finds that the projection method is the least satisfactory, and he uses either the squared micrometer or a camera lucida. Until recently he has used Ashe's, but he is now using an Abbé, which he finds much better than any other he has tried. For thick objects he uses the squared micrometer with squared paper, tracing the outline on to another piece of paper and finishing freehand. Colour, said Mr. Soar, is of secondary importance, and there is no royal road to its successful employment. A good black-and-white drawing is always to be preferred to a poor coloured one. He found coloured indelible inks which may be diluted to the required depth with distilled water very serviceable, but he was unable to say whether they were absolutely permanent. Mr. Soar said that he used Gillott's fine pens and preferred Bristol board to drawing paper. The meeting closed with a hearty vote of thanks to Mr. Soar for his helpful address. A series of drawings and lantern slides were exhibited showing the methods used from the first outline produced to the finished drawing. Several very beautiful coloured drawings were also exhibited.

At the 562nd Ordinary Meeting of the Club, held on June 14th the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on May 10th were read and confirmed.

Messrs. Arthur Reginald Closh and George Craven Pollard were balloted for and duly elected members of the Club. Three nominations were read for the first time.

A list of additions to the Library was read. The Secretary said that he had not yet finished sorting out the deep-sea dredgings that had been presented to the Club, but that he would like to know which members would like samples by the next Gossip Meeting on June 28th. The Secretary read a note from Mr. E. M. Nelson advocating the use of golden syrup as an immersion medium for condensers when the thinness of the slip made it a difficult matter to keep perfect contact with oil. Commander Ainslie said that he overcame the difficulty either by unscrewing the front lens of the condenser or by using a convex lens under the condenser, and that he often used water as an immersion medium. Mr. Merlin exhibited a photograph of *Amphipleura pellucida* in "pearls" taken with direct light and using syrup for immersing the condenser. The Secretary read some "Notes on Parasitic Acari" by Mr. Stanley Hirst. The first note described systems of tracheal tubes observed in members of the families Sarcoptidae and Listrophoridae, which are generally supposed to be destitute of stigmata and tracheal tubes. The second note described the two valid species of Psoroptes, *P. natalensis* and *P. communis*. Mr. Hirst said that although he had examined a large series of Psoroptes from various domestic animals, it seemed certain that with the exception of *P. natalensis* they must be regarded as races or slight variations of a single species. The genus Sarcoptes also consists of a single species. It is, however, very difficult to transfer the mites from one host to another.

The President remarked on the difficulty of transferring fungal parasites from one host to another. There were fungal races peculiar to different hosts, although apparently they were morphologically identical. A vote of thanks was accorded to Mr. Hirst for his valuable contribution.

Dr. W. A. M. Smart then exhibited and described a simple apparatus for finding the refractive indices of oils used in medicine. Briefly, it consists of a biconvex lens laid on a plane mirror. A short pin is held at such a distance above it that image and object coincide. The oil to be tested is run in between the lens and the mirror. From a mathematical calculation the refractive index is obtained. It was shown that the result obtained is reliable to three places of decimals—sufficiently accurate for the purpose for which the apparatus is designed, viz. to test the purity of the oils used in pharmacy. Some suggestions were made by Commander Ainslie that in such a case use might be made of Newton's rings for calculating the refractive index. The thanks of the meeting were accorded to Dr. Smart for his exhibit.

The President then called upon Mr. A. A. C. Eliot Merlin to read his paper on "Some Facts and Fallacies of Practical Microscopy." Mr. Merlin said that his aim in reading the paper was to help beginners to obtain trustworthy microscopical images, by which the true structure of minute objects is revealed and the dangers of erroneous interpretation minimised. In his early days he was initiated into the use of the old high-power Seibert water-immersion lenses which he saw used mostly on diatoms with the "white-cloud" illuminator, or a quarter-inch objective used out of focus as a substage condenser. Frequently these were dispensed with and the concave mirror used alone. The object was to get sufficient light by any and every means. The books at the time gave no practical help. In 1888 he obtained his first oil-immersion objective of N.A. 1·25; this he used on diatoms with an Abbé illuminator and moderate stop, and obtained fairly good views, but the optician who supplied the apparatus advised him to use the smallest stop in his condenser in accordance with the teaching of Abbé. At that time it was considered unthinkable to dispute any of Abbé's inferences from his diffraction theory.

Microscopists were recommended to close down the condenser diaphragm as far as possible and even to cut out the "useless central dioptric beam." Under those circumstances it is hardly to be wondered at that it was stated that with the means employed no definite inference could be drawn of the real structure of the Abbé diffraction plate or of *Pleurosigma angulatum*. Mr. Merlin here quoted the diffraction experiments described by Stephenson in the *Monthly Microscopical Journal*, Vol. XVII, pp. 86 and 87, and he submitted that had Abbé's inferences from his diffraction theory been true, the microscope would have been the most unreliable instrument imaginable. Mr. Merlin was unable to obtain the false effects described, the only result of reducing the aperture being to increase the size of the antipoint and consequently to reduce resolving or separating power. It was at the Q.M.C. that Mr. Nelson read the papers which caused Abbé to modify his ideas in many respects and opened an easy road for the student who is anxious to employ his lenses to the best advantage. Mr. Merlin recommended the study of Mr. Nelson's paper on "The Substage Condenser" read before the Club on May 16th, 1890. He said that if the principles there laid down had been followed by working microscopists in general, enormous strides would have been made in the elucidation of many difficult structures. "Critical illumination," as described by Nelson, consists of focusing the image of a suitable radiant on the object and employing a large working aperture of the objective. The radiant used by Nelson is the edge of a half-inch paraffin lamp flame. Mr. Merlin said that the objections that had been raised to the use of the flame edge on the grounds of its thickness were probably due to the use of a condenser unprovided with an arrangement for making adjustments for slip thickness. It is often impossible to fill the back lens of the objective evenly without this adjustment, which is very rarely fitted to condensers, and for which opticians say there is no demand. The three necessary conditions for good visual work are (1) a large working aperture, (2) a well-defined image of the radiant focused on the object plane, and (3) an unbroken even disk of light at the back of the objective. The lamp flame should be at a distance of about 8 inches. The dry condenser used by Mr. Merlin is the Powell 4/10 apo. of 0·95 N.A. with lever adjustment for slip thickness. It was described by Mr. Nelson in the *Journal R.M.S.* for 1895, p. 231. To obtain the greatest working aperture with the highest powers an immersion condenser of N.A. 1·3 must be used. An immersion condenser is not very sensitive to variations of slip thickness. With a very large working aperture contrast in unstained transparent objects is reduced to a minimum, nevertheless the capacity of a really good objective is utilised to the utmost. Mr. Merlin said that it was highly important that the image of the radiant should be structureless, as is the case with the lamp flame; he objected to the thorium disc on the grounds that its granulated surface might give an image that could be mistaken for structure in the object. Since his return to England he finds the same carelessness as to illumination on the part of most workers as used to be fifty years ago. Abbé condensers are used and the ground-glass incandescent filament lamp is very popular and very unsuitable. Mr. Merlin said that probably the great initial difficulty in observational microscopy is that of recognising the "critical" image. The eye must gradually become accustomed to the often faint but clearly outlined images, which are such a contrast to the strong diffraction effects generally preferred even by microscopists of long standing. In addition to the photograph of *A. pellucida*, Mr. Merlin exhibited one of *P. angulatum* and also one of *Nitzschia singalensis*; the latter showing the striae, and taken with an achromatic oil-immersion objective of N.A. 1·18, the lowest aperture with which this diatom has been resolved.

Commander Ainslie said that he was glad Mr. Merlin had laid such stress on the large illuminating cone and the faint image, but he could not agree that the lamp flame was the only suitable illuminant. No one could tell us what the correct microscopical image was, it could only be judged by mathematical theory. No theoretical reason had ever been given for focusing the illuminant on the object, but unless it was so focused, if the illuminant was small, it was impossible to be certain that the back lens of the objective was filled with light, although it might appear to be so on looking down the tube. Commander Ainslie said that it was possible to see as much but no more with the flame edge as with other illuminants. He attributed the remarkable discoveries of fine structure made by Mr. Nelson and Mr. Merlin not to their use of the flame edge, but to their unusually keen eyesight.

The meeting closed with a very hearty vote of thanks to Mr. Merlin for his paper.

OBITUARY NOTICES.

EDMUND JOHNSON SPITTA, L.R.C.P. (Lond.), M.R.C.S. (Eng.), F.R.A.S., F.R.M.S.

It is with very great regret we have to record the death on January 21st of Dr. Edmund J. Spitta, who for four years was President of this Club. Dr. Spitta was born at Clapham sixty-eight years ago, and after a successful career as a student settled down there in general medical practice which lasted for thirty years. During that period he found time to contribute very largely to more than one branch of microscopical science. When he retired from practice and went to live at Hove in 1904, he had greater freedom and was able to devote much of his time to this subject. It was at this time he became President of our Club, and the enthusiasm and energy which he devoted to the office for four years have had a very marked effect on the prosperity and success of the Club during recent years.

Photomicrography and the optics of the microscope claimed his attention more particularly than the biological side. So far back as 1898 he published in collaboration with Dr. Charles Slater, then Bacteriologist at St. George's Hospital, an *Atlas of Bacteriology*, containing more than a hundred plates of photomicrographs of Bacteria. More recently he brought out his well-known manual of *Photomicrography* (1st ed. 1899). But his chief claim to be looked upon as an exponent of the optics and use of the microscope is his work published under the title *Microscopy*. This has now passed through three large editions, the third being issued only last year (1920). This book is dedicated to the "Council and Members of the Quekett Microscopical Club" and is a general treatise on the construction, optics and use of the microscope.

Dr. Spitta was a man of a sanguine temperament and a somewhat dominating personality, but those who were most likely to disagree with him readily recognised his sincerity.

The use of the portrait of Dr. Spitta (Pl. 5) we owe to the courtesy of the Council of the R.M.S. and the Editor of the *Journal*.

FREDERICK ANTHONY PARSONS, F.R.M.S.

It is with very great regret we have to record the death on February 7th of Frederick Anthony Parsons, in his eighty-fifth year.

Mr. Parsons had been engaged as an Engineer's Draughtsman, until he was appointed Assistant Secretary of the Royal Microscopical Society in 1896. He held this post until 1912, and on retiring he was nominated as a Fellow by the Council, in recognition of his long and valued service, and presented with a testimonial and an address at the meeting held June 19th, 1912. He was a member of the Quekett Microscopical Club for a few months short of half a century, and during that time served for many years as Secretary to the Excursions Committee. It was on April 19th, 1884, on one of the Club's annual visits to the Royal Botanic Gardens, Regent's Park, that he was fortunate in first finding specimens of the freshwater Hydroid Polyp, a biological discovery of much importance. It was taken from the *Victoria Regia* tank, where a few years previously had been found the Medusoid form which had been described by Prof. (now Sir) E. Ray Lankester, under the name *Limnocodium Sowerbyi.*

His kindliness, his enthusiasm in microscopical matters, the thoroughness and neatness which were marked features in everything he did, will be long remembered by all who knew him. Mr. E. M. Nelson writes, "No microscopist I have ever met was more ready than he to help not only in the department of pond life, but also in that of the mechanical construction of the microscope, for he possessed a good knowledge of mechanical engineering."

Charles Frédéric Rousselet.

A NOTE ON THE MEASUREMENT OF THE VERTICAL DIMENSIONS OF OBJECTS BY THE USE OF THE GRADUATED FINE ADJUSTMENT.

By F. Addey, B.Sc.

(*Read October* 11*th*, 1921.)

Figs. 1–5 in Text.

The difference between the readings with two settings of the fine adjustment gives the distance through which the microscope has been moved to or from the object. If the microscope be first focused on the lower surface of the object, and then on its upper surface, the distance through which the microscope has been moved will be equal to the actual depth between the surfaces, if the object be in air. But if the object be immersed in a medium of which the refractive index is different from unity, the apparent depth, as given by the readings of the fine adjustment, will not be the true depth. The correction which has to be applied to the apparent depth to obtain the true depth can be found as follows :

Consider first a cell of depth t completely filled with a medium of refractive index n (Fig. 1). The rays of light from a point P at the bottom of the cell are refracted at the surface as shown in the diagram for one ray PQR. Let the angles which the ray makes with the normal to the surface, in the medium and in the air, at the point where it emerges, be θ_1 and θ_2 respectively.

Then if we consider a fairly narrow cone of rays, such as we should be concerned with in microscopy, we have :

$$\frac{1}{n} = \frac{\sin\theta_1}{\sin{}_2} = \frac{\tan\theta_1}{\tan\theta_2} \text{ (because the angles are small)}, = \frac{d/t}{d/t'} = \frac{t'}{t}.$$

Therefore $t' = \frac{t}{n}$, or the rays of light from the point P appear to be coming from a point P_1, situated at a distance below the surface of the medium only $\frac{1}{n}$th of the actual depth of the cell.

If, therefore, we endeavoured to measure the depth of the cell by first focusing on the surface of the medium, and then on the bottom of the cell, since the bottom of the cell will appear to be at P_1, the apparent depth which we obtain by the readings of the fine adjustment will only be $\frac{1}{n}$th of the true depth, and our observed result must therefore be multiplied by n to obtain the true depth.

Fig. 1

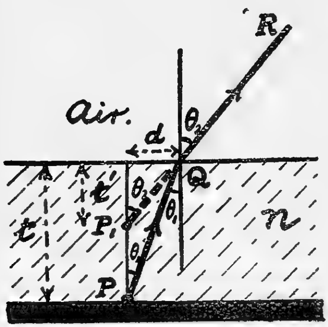


Fig. 3

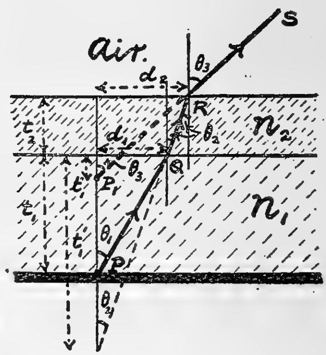


Fig. 2

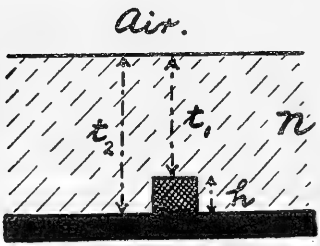


Fig. 4

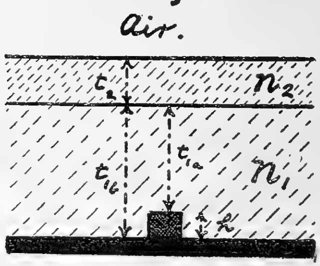


FIG. 1.—Path of a ray from mounting medium to air; no cover glass.
FIG. 2.—Body immersed in mounting medium; no cover glass.
FIG. 3.—Path of a ray from mounting medium through cover glass into air.
FIG. 4.—Body immersed in mounting medium and provided with cover glass.

Consider now a body of vertical thickness h immersed in the medium (Fig. 2).

If t_1 and t_2 be the true distances from the surface of the liquid to the top and bottom of the body, and the apparent distances as measured by the fine adjustment be t'_1 and t'_2 respectively, then we shall have

$$t_2 = nt'_2$$
$$\text{and } t_1 = nt'_1.$$

Therefore $t_2 - t_1 = n\,(t'_2 - t'_1)$.

Now the true thickness, h, of the body, is $t_2 - t_1$.

Therefore $h = n\,(t'_2 - t'_1)$, or the apparent thickness of the body immersed in a medium of refractive index n, has to be multiplied by n to obtain the true thickness.

In the cases we have just considered, the surface of the medium has been assumed to be in direct contact with the air. We have now to enquire what effect is produced when a cover glass is present between the medium and the air.

Consider first the apparent depth of a cell filled with a medium of refractive index n_1 and provided with a cover glass of refractive index n_2. Assuming that n_2 is greater than n_1, the path of a ray from a point P on the bottom of the cell will be as shown in Fig. 3, and the ray when it emerges into the air will appear to come from a point P_1 raised above the bottom of the cell.

If the refractive index of the medium be greater than that of the cover glass, the ray on passing from medium to glass will be bent the other way, but the only result of this will be that the point P_1 will be raised further above the bottom of the cell than it is when the refractive index of the cover glass is the greater. The mathematics will be exactly the same in both cases.

Let us take first the refraction from medium to cover glass. We have:

$$\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2} = \frac{\tan\theta_1}{\tan\theta_2} \text{ (because the angles are small)}, = \frac{d_1/t_1}{d_1/t'_1} = \frac{t'_1}{t_1}.$$

Therefore $t'_1 = \frac{n_2}{n_1} \cdot t_1$.

Take now the refraction from cover glass to air. We have:

$$\frac{1}{n_2} = \frac{\sin\theta_2}{\sin\theta_3} = \frac{\tan\theta_2}{\tan\theta_3} = \frac{d_2/(t_2 + t'_1)}{d_2/(t_2 + t''_1)} = \frac{t_2 + t''_1}{t_2 + t'_1}.$$

But $$t'_1 = \frac{n_2}{n_1} \cdot t_1.$$

Therefore $$\frac{1}{n_2} = \frac{t_2 + t''_1}{t_2 + t'_1} = \frac{t_2 + t''_1}{t_2 + t_1 \cdot \frac{n_2}{n_1}}.$$

Therefore $$\frac{t_2}{n_2} + \frac{t_1}{n_1} = t_2 + t''_1,$$

or $$t''_1 = \frac{t_1}{n_1} + \frac{t_2}{n_2} - t_2$$
$$= \frac{t_1}{n_1} + \left(\frac{1}{n_2} - 1\right)t_2$$
$$= \frac{t_1}{n_1} - \left(1 - \frac{1}{n_2}\right)t_2.$$

Without the cover glass the apparent depth of the medium would have been $\frac{t_1}{n_1}$. Hence the effect of the cover glass of thickness t_2 and refractive index n_2 is to diminish the apparent depth by $\left(1 - \frac{1}{n_2}\right)t_2$, *and this diminution is independent of the depth of the medium.*

Hence the presence of the cover glass has no effect on the apparent thickness of an object measured in the medium, for the effect which the cover glass exerts in apparently raising the object will be equal on both the top and bottom surface of the object, since it is independent of the depth of the medium, and therefore the apparent distance between these surfaces will not be altered.

We can express this algebraically as follows (Fig. 4):

We have:

$$t''_{1b} = \frac{t_{1b}}{n_1} - \left(1 - \frac{1}{n_2}\right)t_2$$

and $$t''_{1a} = \frac{t_{1a}}{n_1} - \left(1 - \frac{1}{n_2}\right)t_2.$$

Hence $$t''_{1b} - t''_{1a} = \frac{t_{1b}}{n_1} - \frac{t_{1a}}{n_1}.$$

Therefore $$n_1 (t''_{1b} - t''_{1a}) = t_{1b} - t_{1a} = h.$$

Thus the true thickness of the object is its apparent thickness multiplied by the refractive index of the mounting medium, the cover glass making no difference.

For water the mean value of the refractive index is 1·336, for canada balsam the mean value is 1·540, and for glycerine it is 1·476.

The following observations confirm the results obtained above.

The depth of a cell on a slip was first measured with the cell empty, and without a cover glass. Cover glasses of various thicknesses were then successively placed over the cell, and the depth of the cell again measured in each case.

Similar measurements were then made with the cell filled with water and with glycerine.

The results obtained are tabulated below :

Medium in Cell.	n.	Thickness of Cover Glass.	Reading on Lower Surface of Cell.	Reading on Upper Edge of Cell.	Apparent Depth (1 div. = 20 μ).	Corrected Depth.
Air . .	1·000	nil	0	44	880 μ	880 μ
Air . .	1·000	6 mils	0	44	880 μ	880 μ
Air . .	1·000	28 mils	0	44	880 μ	880 μ
Air . .	1·000	37 mils	0	44	880 μ	880 μ
Distilled Water .	1·336	6 mils	0	33	660 μ	880 μ
Distilled Water .	1·336	37 mils	0	33	660 μ	880 μ
Pure Glycerine .	1·476	6 mils	0	30	600 μ	885 μ
Pure Glycerine .	1·476	37 mils	0	30	600 μ	885 μ

The measurements of the depth of a cell just given, although quite sufficient to confirm the theoretical deductions made above, are not quite the kind of measurements which would usually have to be made in practical work. We should more likely be concerned with the thickness of some portion of an object which was quite immersed in the mounting medium. The following is an example of such a measurement.

After some search for a suitable object, the claws on the hind legs of a cat flea, *Ctenocephalus felis*, mounted in pure glycerine, were chosen. In this particular mount the legs happened to be so arranged that one claw on one foot was lying horizontally, while one claw on the other foot was directed vertically. Since the two claws on the same foot are approximately of equal length, and since it is a fair assumption to consider that the claws on corresponding legs are equal to one another, we have thus two equal objects, one lying across the line of sight, and one lying at right angles to it. A camera-lucida drawing of the claws is shown in Fig. 5. The length of the claw lying across the line of sight was measured with

Fig. 5.—Hind claws of cat flea, *Ctenocephalus felis*. × 250.

the eye-piece micrometer, while the vertically directed one was measured with the graduated fine adjustment.

The results obtained were as follows :

Vertically directed claw :

3·25 divisions = 3·25 × 20 μ = 65·0 μ apparent length.
65·0 × 1·476 (the refractive index of glycerine) = 95·8 μ.

Transversely directed claw :

Micrometer measurement = 93·15 μ.

This again confirms the theory given above.

ON THE FOCUS-APERTURE RATIO.

By Edward M. Nelson, F.R.M.S.

(*Read December 13th,* 1921.)

Figs. 1–5 in Text.

Probably everyone will agree that this important point in the economy of the microscope is in a deplorable condition. Microscopists have a vague notion that if an objective has too much aperture (N.A.) for its power, although, when a slotted condenser is used, it will resolve a great number of lines to an inch, nevertheless, for ordinary microscopical work with axial illumination the lens is not satisfactory; chromatic and spherical aberrations are sure to be in evidence. On the other hand, if an objective has too small an aperture, the image given is similar to that seen in a microscope purchased as a present for a schoolboy! Obviously, therefore, somewhere between these two limits there will be a condition which is correct. But what is that condition? It is with a view to answering that question this paper has been written. This subject has been previously dealt with upon three occasions, about the same time, by Prof. Abbe, the Royal Microscopical Society, and myself.

The ratio of aperture to power (or what is the same thing, to focus), as suggested by Prof. Abbe, leans very much towards the schoolboy's microscope; so much so that lenses with such a low ratio of aperture to power have seldom been made, and it would be difficult to obtain a specimen to see what they are like. In my collection there is only one modern example; it is a cheap 1 in. formed by a single achromatic combination. It is well corrected, but as it lacks the required N.A. it is never used. For other examples it is necessary to examine object glasses made in 1840, or earlier. When you are told that Prof. Abbe's ideal 1/4 in. has an aperture of N.A. 0·41, and his 1/8 in. of N.A. 0·65, you will see that we need not detain ourselves any longer over his list.

The Royal Microscopical Society's official list seems to have been drawn up at random, certainly not upon any kind of plan;

it was probably compiled partly from opticians' catalogues. My own list was formed on a plan which was theoretical, not practical. The plan, consisting of two parts, was very simple; the first part was to find out the resolving power of the human eye. This was determined from observations of my own sight to be 1/250th of an inch at 10 in. The second part of the plan was to find out the N.A. necessary to resolve this amount with a given objective, when used with an eyepiece multiplying by 10 for a long tube (*C* eyepiece) or 15 for the short tube. In addition, a term "Optical Index" was introduced [1]; this was obtained by multiplying the N.A. by 1,000, to clear it of decimals, and dividing by the initial magnifying power. Example:—Nominal 2 in., initial magnifying power 6·67 (actually, therefore, a $1\frac{1}{2}$ in.), N.A. 0·167, multiply by 1000 = 167, divide by 6·67 = 25 = Optical Index. If the lens was a good one it would resolve, say, 16,700 lines to the inch. Its magnifying power with a *C* eyepiece would be 66·7, and consequently an eye capable of seeing 250 lines to the inch would be required to observe that resolution, since 66·7 multiplied by 250 = 16,700. Therefore, object glasses to fulfil the conditions of this plan must have an optical index of 25. This rule may be put in other words, *viz.* each objective must have N.A. 0·25 for each increase in initial magnifying power of 10. Examples, 1 in., N.A. 0·25; 1/2 in., N.A. 0·5; 1/4 in., N.A. 1·0; 1/10 in., N.A. 2·5. The higher powers are, however, impossible of construction, hence the plan must be called theoretical. This plan was adversely criticised at the time (40 years ago), but since then this eye-limit has been adopted by oculists, and with the lower powers the N.A. limit has been exceeded.

The reason for introducing the term "optical index" was for the purpose of providing microscopists with a term similar to that used by photographers, who call the speeds (squares of the aperture) of their lenses U.S. 1, 2, 3, etc.—unity being, as all know, *f*/4. Now *f*/4 is the same as N.A. 0·125, or the aperture that a lens, whose initial magnifying power is 5 (a nominal 3 in.), should possess.[2]

[1] *Journ. R.M.S.* 1893, p. 12.

[2] The precise difference between optical index and *x*, in *f*/*x*, consists in *f*/*x* being based on a tangent whereas optical index is based on a sine. With low ratios the difference is negligible, because the sines and

But it is not always advisable to adhere to a theoretical limit; we ought to be satisfied with something less, and not try to work up to a breaking-point. After half a century's almost constant work with a microscope, and an acquaintance with an enormous number of all kinds of objectives, I think the Club will not object to my bringing to its notice a power-aperture curve, derived from my own practical experience. First, let me point out that a tabular list of objectives giving their foci, powers, numerical apertures, and optical indices is of little value, for the mind cannot take it in at a glance. A curve must be drawn from the tabular data and exhibited to the eye for judgment. Now, it will be perfectly clear to all our members that a curve, drawn upon any plan at all, must be a smooth curve. For example, the graph of the plan just dealt with, having an optical index of 25, would with ordinates powers and abscissae N.A. be represented by a straight line, drawn at an angle to the base, with a tangent of 0·4, or $22\frac{3}{4}°$. This angle is small, because the plan is based upon a high ratio; if, however, we were content with a lower ratio, say N.A. 0·2 for each additional 10 in initial magnifying power—that is, optical index 20—the straight line would make the larger angle of $26\frac{1}{2}°$ to the base, and with optical index 10 it would be 45°. We can then tell at once, from the angle the line or curve makes with the base, whether the graph is that of a wide or narrow angled scheme. (A straight line making an

tangents of small angles are nearly alike. With wide angles, however, an error would come in. The true value of x is $\frac{1}{2\text{N.A.}}$. Example :—The semiaperture angle of a lens $f/4$ is tan 1/8 = 0·125, this is 7° 7′ 30″; but the true aperture of that lens should be measured by the sine or 0·124, etc. Now, as the rapidity of lenses is as the squares of their N.A.s, a lens of double the N.A. would have four times the speed; but double sine 0·124, etc., is equivalent to an angle of 14° 21′ 48″, which represents $f/1·9525$, and this is the true value of a lens having four times the speed of one of $f/4$. By the photographer's scale, calculated from the tangent, we have $f/2$, or tan 1/4, which is an angle of 14° 2′ 10″, and this is too small. Therefore, a lens $f/2$ has not four times the speed of one of $f/4$. The diameter of a photographic lens, 8 in. focus, having four times the speed of a lens $f/4$, according to a photographer's scale, is $f/2$, or 4 in., whereas its true value is 4·1 in. The visual resolving power of a lens is $45287/x$, and its photographic $58494/x$ lines to the inch. (See my table of correct apertures for U.S. numbers in *The British Journal of Photography*, January 12th, 1891.)

angle of 45° with the base would represent an inch of N.A. 0·1, a 1/2 inch of N.A. 0·2, a 1/3 inch of N.A. 0·3, and so on—a ratio of course ridiculously small.)

When we plot the ratios suggested by biologists and medical men, who demand full apertures for, say, the 1 in. (with short tube 2/3rd in.), a lens they use, but for their medium powers low angles for penetration, etc., we shall not find a smooth curve, but a zigzag line, like a flash of lightning. All that a microscopist

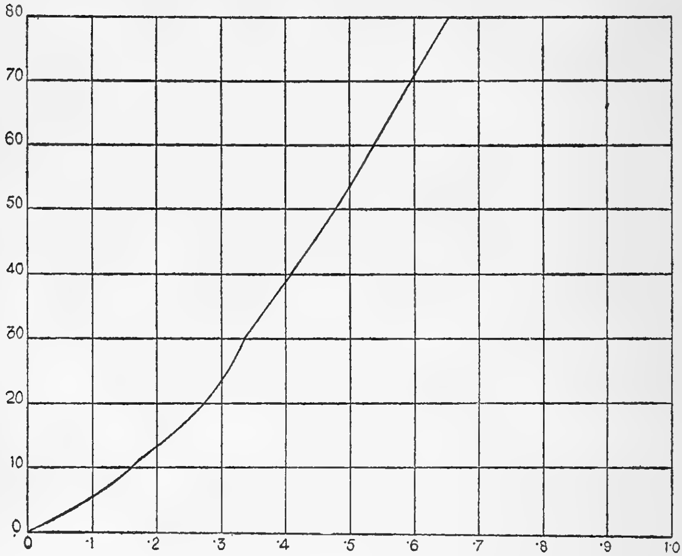


Fig. 1.

has to do is to plot the curve, and he will have no hesitation in appraising the value of a proposed scheme, as to its soundness or worthlessness, for he will see it at a glance; remembering, of course, that the more the line inclines to the horizontal the greater will be the relative apertures, and, conversely, the more to the vertical the smaller they will be.

My new curve, practical not theoretical, has been based upon an optical index, diminishing in quantity as the powers increase; and you may be quite sure that all microscopists of experience will assent to the soundness of this principle, for they know that 2-in. and 1½-in. objectives with large optical index can be made with their optical aberrations beautifully corrected, also that opticians are unable to keep up these conditions as the powers increase. If then the corrections of the higher powers are to be maintained at the same excellence as the lower ones, down must come the optical index. The conditions with photographic lenses are the same; lenses of *f*/16 giving sharp images are common and cheap, but when they rise to *f*/6·5 they are scarce and expensive;

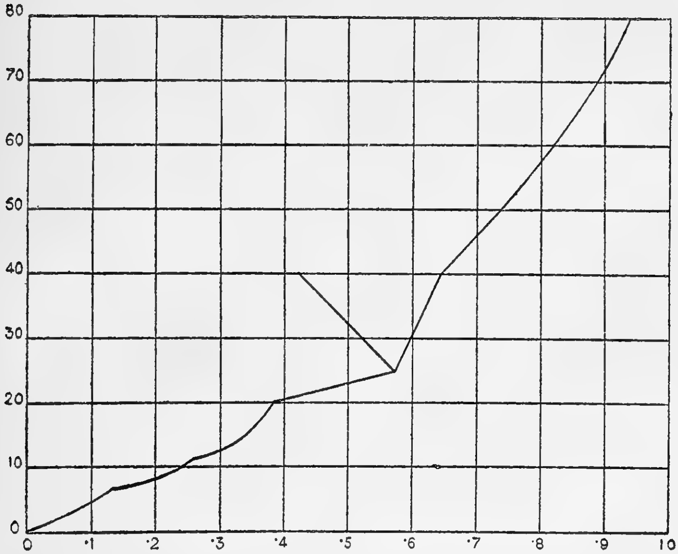


Fig. 2.

beyond that opticians introduce "atmosphere," only another word for imperfect correction.

In plotting the curves, each of the squares represents 1 inch. The first is that of Prof. Abbe (fig. 1). Here we see, at once, that the line is at a high angle with the base, also that the curve is not smooth. From 0 to 12 is one curve, from 12 to 30 is another, and from thence to 80 is a straight line. The chief fault of this curve is its high angle with the base; it therefore represents a class of objectives endowed with much "empty magnification."

The next is the R.M.S. curve (fig. 2). You will notice, at once, that it is anything but a smooth curve; its trend is much more towards the horizontal than Prof. Abbe's. It starts with three different curves to the 1/2 in., from there to the 4/10th it is very flat, here its designer seems afraid that he has run away too far from Prof. Abbe, so he has made two quarter-inches, one with only a little more aperture than the Professor's, and one with a good deal more; but notice that this higher aperture 1/4th has a steeper slope than their other higher powers; the line from the 1/4th to the 1/5th, for example, inclines more to the horizontal, showing that it has a wider relative aperture, when, of course, it should incline the other way. This bears out the previous statement, that this curve is based upon no plan.

The Germans, as is well known, keep to their catalogue values fairly closely, so it will be unnecessary to draw two curves, one for the catalogue values and one for actual values, as the curves would be very similar. A curve drawn from 17 measured German objectives is not a smooth curve; there is a kick about the 4/10th, from there to the 1/3rd it is nearly horizontal, and thence it slopes up pretty steeply. It shows that a lens of power 25, *viz.* a 4/10th, has an aperture of N.A. 0·4, whereas the R.M.S. shows N.A. 0·57 and Prof. Abbe's one of N.A. 0·32. After the 4/10th the curve is smooth, and not very unlike that of the R.M.S. plan.

Now we come to English measured objectives. To draw a curve from a catalogue would be useless, as the difference between catalogue and measured values is so great. A catalogue 1/2-in. of N.A. 0·65 (optical index 32·5), when measured, would probably be a 4/10th of N.A. 0·55 (optical index 22·0), and a 1/4th of N.A. 0·7 (optical index 17·5) is very likely a 1/5th of N.A. 0·67 (optical index 13·6). The measurements of English lenses always show a decrease of optical index from what the catalogue would lead you to expect.

The English curve is one of high relative apertures, for it tends to flatness; there is the usual kick about the 1/2 in., and a worse one between the 1/5 and 1/6. It was drawn from the measurements of 26 objectives by various makers.

We now come to my own curve (fig. 3), which I ask you kindly to take into your consideration. You will notice at once that it is a smooth curve, therefore it has been drawn upon a plan; there is no kick at the 1/2 in., nor anywhere else. The optical index is gradually diminished as the powers increase. The low powers up to the 4/10th have an optical index of about 20, so that part of the curve is nearly a straight line, making an angle of 26° 36′ with the base. There is no lens in the whole curve that will cause a manufacturing optician a moment's anxiety. A 4/10th in. of N.A. 0·5 cannot be said to have an excessive aperture, and such a lens is of the greatest possible value in biological and other work. After the 4/10th the optical index is reduced and the curve becomes steeper. The curve has been drawn to an objective 1/8th, of N.A. 0·9; but of the utility of an achromatic dry lens of that aperture I have grave doubts. Prof. Abbe stated

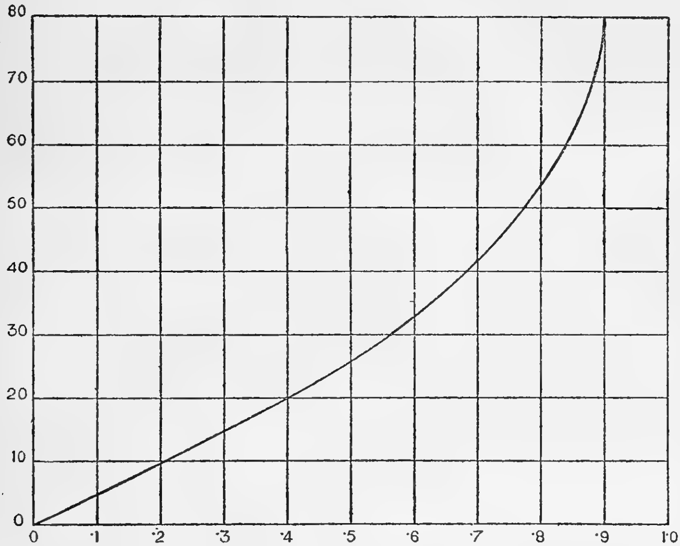


Fig. 3.

that an angle of 110° was the limit for perfection in a dry lens (say 1/6 in. of N.A. 0·82 (optical index 13·7), and I agree with him.

Anyone who will take the trouble to compare the image given by an oil immersion 1/7 in. of N.A. 0·9 (introduced not long before the war) with that from a dry 1/7 or 1/8 of even greater N.A. will probably be convinced that high-power dry lenses with large apertures are a mistake. My curve was drawn to the top, so that it might be compared with the others, otherwise it would have been stopped at N.A. 0·85 (optical index 13·5). There is nothing else to be said, or explained, as the curve speaks for itself, which no list of objectives and apertures could do nearly as well. It should be understood that the apertures of objectives are designed for an integral number of degrees, and not for a rounded-off N.A. Example :—A lens would not be made N.A. 0·33, which is 38° 32′, but would be constructed with an angle in air of 38° or 39°.

Now to pass on to Apochromats. Apochromatism is an invention which enables opticians to enlarge the ratio of aperture to focus. In the lower powers it is not needed, because a sufficiently large ratio can be obtained without it. Objectives of 3 in., 2 in., and 1½ in. were made sixty years ago of excellent quality, with large optical indices; but when the powers are increased to the 1/3 in. and upwards, the advantage of apochromatism will be evident, and consequently the curve need not begin to bend up so soon. Three curves have been drawn; two, on one chart, showing the existing apochromats. The low-power apochromats are freak lenses: for example, a 1 in. of N.A. 0·3 is useless; no microscopist who had a 2/3 in. of N.A. 0·3 would ever use the 1 in. of N.A. 0·3. The same may be said for the 1/2 in., a 1/3 in. of the same aperture is by far a more useful object-glass. A 1/4 in. of N.A. 0·95 is much more of a freak; if its aperture were reduced to N.A. 0·8 it would be a very serviceable lens; while a 1/6 of N.A. 0·95 is a most useful glass, and is the limit for a dry lens. If you will examine these two curves you will see the usual kick about the 2/3 in.; it indeed seems a strange practice to underdo the 2/3 and overdo the 1/3, when there can be no possible reason for it. Now, if you will kindly examine the apochromatic curve (fig. 4), you will see that, like the previous one for achromats, it is a smooth curve without any kick, and by comparing these two you will find that the apochromats and achromats have both the same "jumping-off" ground, but that the apochromats have far more "staying" power. The last curve is one I have drawn for oil immersions (fig. 5). Here we encounter very much reduced optical indices. It begins with a 1/7 in. of N.A. 1·0 (optical index 14·3) and practically ends with a 1/12 in. of N.A. 1·4 (optical index 11·7), but as some microscopists use a 1/16 in. of N.A. 1·3 (optical index 8·1) the curve is continued to show its backward march.

A 1/18 in. of N.A. 1·3 (optical index 7·2) is made, but it is difficult to see the use of such a lens. The curve for it would follow on vertically two squares above the 1/16 in. It is often said that there is not much difference between the fluorite 1/12th of N.A. 1·3 (optical index 10·8) and the apochromatic 1/12th of N.A. 1·4 (optical index 11·7), nor is there in catalogue values; but if a curve were drawn from actual object glasses, many fluorite 1/12ths would appear with optical index 9·0, for they often really are 1/14ths of N.A. 1·26. The curve would therefore be much steeper than mine. In conclusion, I submit these three curves, for achromats and semiapochromats, for apochromats, and for

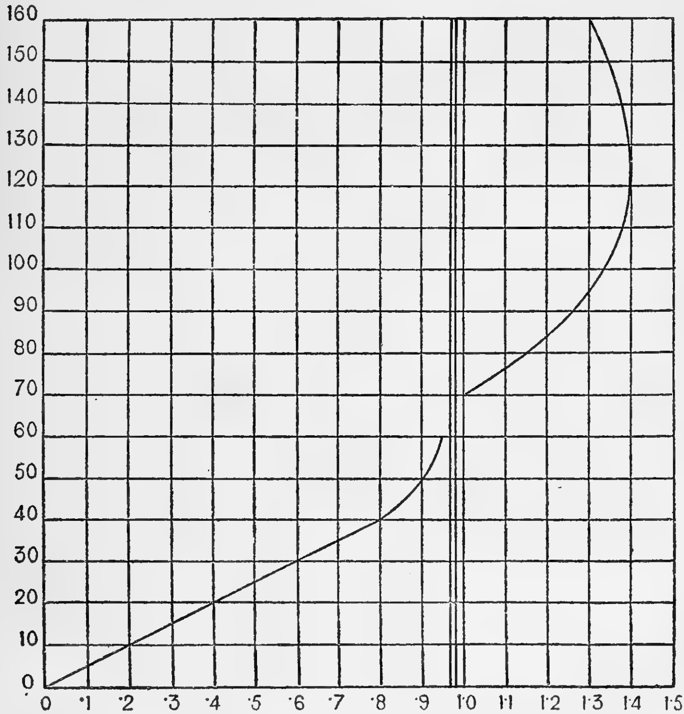


Fig. 4. Fig. 5.

oil-immersions, to the Club, as the first smooth curves that have ever been drawn on a plan for the construction of microscope objectives.

When this Club was founded, teaching the use of the microscope to beginners was one of its aims; this paper, dealing as it does with object glasses, invites such a course. Microscope objectives may be likened to the musical gamut, for musical notes are higher and lower than one another, and so are objectives in power. Music is arranged in keys, and so may be objectives—for example, we have—

Key A. 4, 2, 1, 1/2, 1/4, 1/8, 1/16 in.
Key B. 3, 1½, 2/3, 1/3, 1/6, 1/12 in.

Besides which there are some sharps and flats, interlopers, 3/4, 4/10, 1/5, 1/7, 1/9, 1/14 in.

Eyepieces also can be arranged in keys thus :

Key 1. Achromats and Complanats, × 5, × 10, × 20, × 40.
Key 2. Achromats and Complanats, × 7½, × 15, × 30.
Key 3. Compensating, × 8, × 12, × 18, × 27.

Note, the above is not mere rhetorical embroidery, but a part of a microscopist's training is to have in his mind some such classification of objectives and eyepieces. It is quite obvious that at the present time, whatever may have happened in pre-war days, none but a millionaire would ever think of buying all the lenses of both keys; it therefore becomes a question of great importance which are the best lenses to have. But with regard to our new members, we surely should hold out to them a helping hand, and not leave them, as we have done hitherto, to find this out for themselves—in other words, to buy their own experience at considerable loss.

At the outset, obviously, the first point to be decided is the choice of key. Is it to be A or B ? I am not going to decide this point for the tyro, but will merely remark that when once the key is chosen, it is bad policy to depart from it and play with lenses in another key. Passing by, then, the debatable points, a few hints from an old microscopist may be helpful to beginners.

Here is an epigram to start with: A wise microscopist has a battery rich in low powers; when beginners take up microscopy they, almost without exception, rush after high powers. This is not merely an error, it is sheer recklessness. A good 2 in. and a 7½ eyepiece is a most important combination, for it will open out the worlds of entomology, botany, pond life, forams, the sea life of rock-pools, geological sections, etc. There is no other lens that can do half as much or be so often generally useful.

If a beginner says, I am not going to study any particular subject, but I wish to see for myself something of those microscopical things which are at present hidden from me, but my battery must be limited to two objectives and two eyepieces, which should I get? The answer is 1 in. and 1/4 in., with × 5 and × 10 eyepieces. Another says the same, but is prepared to have three objectives and three eyepieces; the answer in this case would be 2 in., 1/2 in., 1/8 in.* and ×7½, ×15, ×12§ eyepieces.[1] Another the same but with four objectives and four eyepieces; then the answer would be 2 in., 1/2 in., 1/4 in., 1/8 in., and × 7½, × 15, × 8§, and × 18§ eyepieces. Five objectives form a complete set, the 4-in. and 1/16-in. of key A and the 3-in. of key B may be regarded as luxuries. The above selections apply to general microscopy only. To give an example of special microscopy, suppose a student says, I am going to study bacteria and nothing else, and the limit of my battery is three objectives and three eyepieces, then his best selection would be a 2/3 in., 1/3† in., and 1/12* in., with × 7½, × 8§, and × 18§ eyepieces. This is the sort of scale that is to be found in most makers' catalogues, but it is a most unsuitable one for general work. For pond life, with three lenses and three eyepieces, the series would be 1½ in., 2/3 in. and 1/3† in., with ×7½, × 15, and × 12§ eyepieces.

With regard to the foregoing lists there can be "no probable, possible shadow of doubt, no possible doubt whatever!" as saith the Grand Inquisitor.

From a very old saw we learn that time is money. Now, much time is spent with a microscope in "finding," and it is obvious that that microscope which shortens this time as much as possible is economically the better instrument. It is also equally obvious that the time spent on "finding" is inversely proportional to the area of the field. We therefore can compare the relative economic values of the English and Continental microscopes, with reference to time saving, by the measurements of fields. With equal powers, the area of the field of the English microscope is about three times that of the Continental, so an object could be found with an English microscope in one-third of the time. Therefore a purchaser may expend three times as much upon an English stand without suffering loss! An hour spent upon "finding" is by no means an uncommon incident; if this can be

[1] † means apochromat, § compensating, and * oil immersion.

reduced to 20 minutes there will be a great gain, not only of time, but also in saving of fatigue to the observer.

One more point and I have done. It is on a subject intimately connected with the objective, *viz.* the measurement of the magnifying power, and this is also in a deplorable condition.[1] It is the desire of some to dethrone English systems and to replace them by German methods. Now, there are two systems for the measurement of magnification in use in Germany, but no reason has been put forward why one method should be chosen in preference to the other, and, of course, the wrong one has been chosen. The Zeiss method, the inferior of the two, uses the initial power of the objective, but gives to the eyepiece power adjusted to the tube length; while the Leitz system more scientifically gives the initial magnifying power to the eyepiece and an adjusted one to the objective. If you will consider for a moment the optical conditions you will see that the front foci of the eyepieces lie at a fixed point, whereas the back foci of the objectives travel up and down the tube according to their powers and constructions. All know that a low-power achromatic lens has its back focus high up the tube, thus shortening the optical tube length and so reducing the power. It is therefore a function of the objective that reduces the power and not that of the eyepiece, consequently the objective ought to have the adjusted power and not the eyepiece. Here follow examples of each. 1st-Zeiss method: No. 1 eyepiece, focus 50 mm. power adjusted to 150 mm. tube, × 3. Objective 36 mm. initial magnifying power, × 7. Combined power, 21. 2nd-Leitz method with the same eyepiece and objective: Initial power of eyepiece × 5. Power of objective adjusted to 150 mm. tube, × 4·2. Combined power 21,

[1] Surely "deplorable" is not too strong a term to use; for example, there are four modern 1/2-in. object glasses on my table, and here are their measured values:

	Initial Power.	N.A.	Optical Index.
1/2 inch	21·5	0·337	15·7
1/2 ,, ...	22·0	0·42	19·1
1/2 ,, ...	24·7	0·65	26·3
1/2 ,, ...	28·0	0·64	23·8

The numerical apertures vary, so that some are nearly twice as much as others; and one 1/2 in. is almost a 4/10 in., and another is very nearly a 1/3 in.; the optical indices vary from 16 to 23.

of course the same as before ; but this method reveals the correct optical principles upon which it is based, while the other is a mere juggling with figures.

In our trade catalogues the Zeiss, or inferior, method has been selected, and it usually appears somewhat after this fashion: Objective, 40 mm. focus, code word "Jabber," initial power 6·3. Eyepiece, 40 mm. focus, code word "Wock," initial power 3·7. Combined power 23. Here we have two lenses of the same foci with their initial powers depending upon whether their code names are "Jabber" or "Wock!"[1] The initial power of a lens is 10 divided by its focus in inches (that is, 10 times the reciprocal of its focus), and this bears no relation to its code name, however facetiously chosen.

It is to be hoped that the members of this Club will refrain from substituting "adjusted" for "initial" magnifying power, and will designate the initial powers of their eyepieces correctly, and put the allowance for tube length in the place where it should be, that is on the objective.[2]

The old English system was a very good one: it consisted in giving fictitious names to the lower-power object glasses. Thus a true 2 in. was called a 3 in., a 1½ in. a 2 in., and so on up to the inch which was really 0·9 in. So one would take the initial magnifying power of their 2 in. as 5 whereas it was really a 1½ in. with an initial power of 6·7. Powers higher than 1 in. could be used without artifice, but our manufacturers nevertheless gave them fictitious values to enable them to palm off lenses with low optical index upon unsuspecting purchasers. This procedure has had much influence in driving the microscope trade out of the country. A student, for example, buys an objective and thinks he has got a 1/4 in. of N.A. 0·7, the optical index of which is 17·5, but the lens that he does get is a 1/5 in. of N.A. 0·65, the optical index of which is 13, a very different thing. The Germans, on the other hand, have adhered pretty closely to their catalogue values, and by so doing have secured a good market for their objectives.

If schemes of the ratios of aperture to power, such as suggested in this paper in curves (figs. 3, 4 and 5), are adopted, then it follows that initial magnifying power and N.A. will practically become synonymous terms. So, instead of saying that with an outfit of two

[1] Beginners should know that a Zeiss compensating Continental eyepiece ×8 is a great deal higher in power than the new Telaugic × 10. With the same tube length and same objective, the 8-power compensating gave a combined power of 188, while the Telaugic gave one of 160. No textbook gives the slightest warning or even information upon this microscopical trap.

[2] Since this was written, catalogues have been issued, in which this nomenclature has been adopted.

objectives only the best lenses to have are the 1 in. and the 1/4 in., it could be said that the best lenses were those of N.A. 0·2 and 0·68. The advantage of this nomenclature becomes evident when we consider that a 1 in. and 1/4 in. means one thing on an instrument having a long tube, but quite another thing on one having a short tube. Now, the conditions to be expressed are, that for observational purposes the best combined powers, with two eyepieces, are 50, 100, 200, and 400, with N.A. 0·2 and 0·68. If therefore the lenses are defined by their numerical apertures instead of by their foci, the subject is cleared of all ambiguity, whether the microscope have a long or short tube.

The delineation of an object depends on the N.A. of the objective and not on the magnifying power, therefore this new nomenclature would be quite rational. So we may say that with two powers and two eyepieces the best objectives to have are N.A. 0·2 and N.A. 0·68.

Now, anyone can see that a long tube has an advantage, for if it is given that for observational purposes the powers should be 50, 100, 200, and 400, these powers can only be obtained with a short tube microscope by either a shorter focus lens or by a deeper eyepiece, both of which are disadvantageous.

As there are some hundreds of thousands of old eyepieces in use, a table of the new powers allotted to them will be necessary, especially as objectives are now engraved with their new multiplying powers. Obviously if these new objective multiplying powers are used with the old eyepiece multiplying powers, serious errors will arise.

Numbers	1	2	3	4	5	6
A . .	5	6·25	8·33	10	12·5	—
B . .	5	6	8	10	12	—
C . .	—	—	10	15·6	20	—
D . .	—	—	7·8	—	13·5	—
E . .	—	—	7·6	—	—	—
F . .	4·4	5·8	8·8	11·6	17·3	—
G . .	4·9	5·95	7·35	9·25	11·35	17·3
H . .	2	4	6	8	12	18
K . .	2·8	5·6	8·3	11·1	16·7	25

A to E, Huyghenian. A, powers of Zeiss and most other Continental makers. B, Leitz powers, the old and new are alike. C, exception by Spencer. D, exception by Koristka. E, exception by Bausch and Lomb. F, Winkel's Huyghenian and Complanats. G, Winkel's compensating. H, Abbe's old powers, compensating, used by all makers except Winkel. K, their new values. Example: The power of an object-glass engraved 10, when used with an Abbe 18 eyepiece is not 180, but 250, as shown in the above table.

THE OXFORD UNIVERSITY EXPEDITION TO SPITSBERGEN, 1921.

By Julian S. Huxley,
Fellow of New College, Oxford.

The Oxford University Expedition to Spitsbergen grew out of the desire of some Oxford ornithologists to visit Arctic lands. They secured the co-operation of zoologists, and finally it was decided to equip an all-round scientific expedition, including also geologists, glaciologists, an exploring and surveying party, and botanists.

Many scientific expeditions had previously been despatched to Spitsbergen, but most of these had been concerned either with exploration, mapping and descriptive geology, or with the collection of animals and plants. The chief strength of the Oxford expedition was biological, and its aim on this side was not so much the recording of old or the discovery of new species as a study of life in the Arctic from an ecological standpoint.

The biological side was again divisible into a strong ornithological section led by the Rev. F. C. R. Jourdain, and a general section led by Mr. Carr-Saunders and Mr. Huxley. The ornithologists made a very thorough survey of many localities on the west and north coasts, and brought back a fine collection of eggs and skins, a set of photographs of Arctic birds unsurpassed for variety and number, largely taken by Mr. Seton Gordon, the expedition's official photographer, and important notes on the habits of many little-known species. The only ornithological work on such a scale previously carried out in Spitsbergen was that of König, and the Oxford expedition extended and amended his results in many particulars.

In the section of general biology, thanks to the co-operation of the botanists, Messrs. Walton and Summerhayes, with the zoologists, Messrs. Carr-Saunders, Elton and Huxley, considerable progress has been made with the study of the ecology of Arctic land and fresh-water animals. In the Arctic the conditions are simple, the number of species few, and the ecological problem accordingly reduced to its simplest form. It is hoped that when the data are properly correlated, the results will be of considerable general interest.

Although the object of the expedition was not primarily the discovery of new forms, a considerable number of new species were actually discovered—to date 5 diptera, 1 collembolan, 1 tapeworm (new genus), 1 ascidian, 5 oligochaetes, 1 spider, 1 rotifer (new to science), in addition to a large number of new records for Spitsbergen.

The collections of the remarkable plant fossils from the Jurassic and Tertiary are the first large collections of these forms—interesting because of the change of climate which they imply—which have been brought back to England. Some paleozoic corals have also proved to be of interest.

The exploring party, comprising Mr. Odell, Mr. Frazer and Dr. Longstaff, penetrated a considerable distance across New Friesland, mapped a hitherto unsurveyed area, and altered and extended our views of the geological structure of the eastern part of the main island.

The separate papers embodying the results of the expedition will be bound up together and issued with a preface by the Clarendon Press. Mr. Jourdain has a book on Spitsbergen birds in preparation, while Mr. Carr-Saunders and Mr. Huxley are preparing a volume on the general scientific problems presented by Spitsbergen. Mr. Seton Gordon has issued a popular account of the natural history under the title *Amid Snowy Wastes.*

A SPECIES OF HYDRACARINA FOUND AT BEAR ISLAND, JUNE 17th, 1921.

THE OXFORD UNIVERSITY EXPEDITION TO SPITSBERGEN, 1921.

REPORT No. 4.

By CHAS. D. SOAR, F.L.S., F.R.M.S.

(*Read May 9th*, 1922.)

FIGS. 1 TO 7 IN TEXT.

THROUGH the kindness of Mr. Elton, of New College, Oxford, two tubes of mites were forwarded to me for identification. In one tube the mites had been preserved in a 5 per cent. solution of formalin, in the other they were in a glycerine solution. With these tubes I received the following notes :

" Found in shallow water at the edge of a large loch called Ellas Lake, near the coast in the S.W. of the island, crawling over stones; their slow movements suggest they were just in the process of losing the power of swimming. The size and colour of these mites vary enormously. They were in all combinations of reddish-brown and green; the eyes were brilliant red. The only other inhabitant of any size was a small caddis larva; the mites crawled over these without either interfering with the other. The mites were in large numbers. There would appear to be very few animals upon which they could be parasitic in the larval stage, since they only occur in this one piece of water and there were no insects except dipterous larvae—chiefly chironomids and the caddis. No beetles or bugs were found at all in the tarn, and none have been recorded for any part of the island in fresh water."

On examination I found them all to be of the same species : *Sperchon lineatus* Sig Thor—a species described by him as found in high mountain districts in cold water in Norway.

It is curious that where this mite was found in Bear Island only one species was obtained. How it arrived there in the first instance can perhaps be accounted for. As far as we know, all species of Sperchon deposit their ova on stones, or in the green slimy growth on stones, thus it would be quite easy for birds to convey the ova on their feet from one district to another. In the Bear Island collection although only one species was found it contained males, females and nymphs. The colouring these mites usually exhibit in life had been lost in the preservative solution, but they showed all the external structure necessary for identification. At first sight they are very like a mite recorded by Mr. Halbert from Co. Waterford and since found in Northumberland, known as *Sperchon brevirostris* Koen. It is like it in colour, size, and general appearance; however, on closer inspection it is seen to differ in at least three important characters: the skin texture, the capitulum, and the genital area. The females vary very much in size, but they are about the same as *S. brevirostris* Koen., ovate in shape. The skin, instead of being papillated as in *S. brevirostris* or *S. glandulosus*, is provided with a system of fine raised lines or ridges; these lines are not straight but more or less curved and under a $\frac{1}{4}$-in. objective have very much the appearance of the skin at the tip of the human finger (Fig. 4). On the dorsal surface (Fig. 2) are two pairs of conspicuous chitinous plates, which Sig Thor says have a bluish tint. The dermal glands are small.

The distance between the small ends of the first pair of epimeral plates behind the capitulum varies in different specimens, but I found none that quite met (Fig. 1).

The capitulum is short and broad; it differs from *S. brevirostris* in the folds in the side walls. Walter points out that in *S. lineatus* the folds number six or seven, whereas in *S. brevirostris* there are quite a number.

The genital area (Fig. 6), which is about 0·30 mm. long and 0·20 mm. broad, differs from that of *S. brevirostris* in having the acetabula shorter, wider, and, as Sig Thor points out, when viewed sideways are almost hemispherical and attached to a kind of foot.

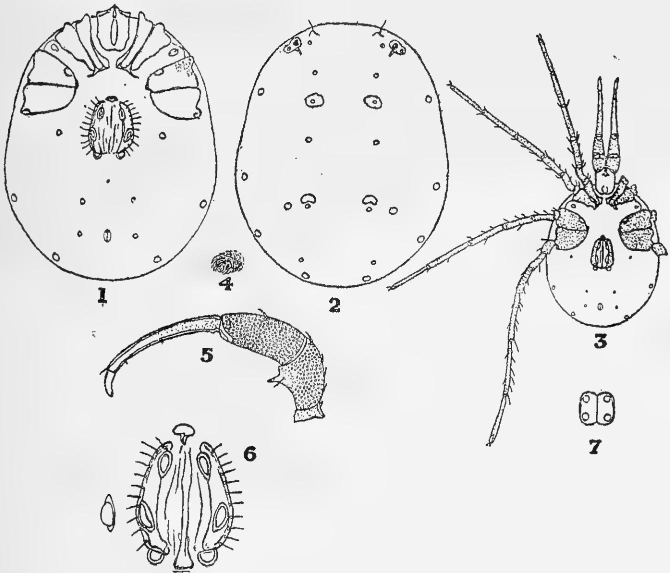
The palpi (Fig. 5) do not show sufficient difference to call for any remark, except that on the extensor edge of the third segment there is one single bristle; in *S. brevirostris* there are usually two or three.

The anal glands vary a little in position in different specimens, in some being in direct line with the anus, in others a little nearer the posterior margin.

The male (Fig. 3) requires no special note; it is a little smaller than the female.

The nymph is about 0·80 mm. long; provisional genital area (Fig. 7) with four acetabula only.

To make sure that the mite had been correctly identified, I wrote to Dr. Sig Thor, sending him tracings of my figures , he was away from Norway at the time, but he wrote back saying, " Your Sperchon is probably a variety of *S. lineatus*, but it is difficult to say definitely from figures alone." However, after going carefully



FIGS. 1–7.—*Sperchon lineatus.*

through Dr. Sig Thor's original description and Dr. Walter's description of some found in Sweden, I fail to find sufficient difference to justify it being described as a new variety, so I record it as *Sperchon lineatus* Sig Thor.

DESCRIPTION OF FIGURES.

Fig. 1. Ventral surface, ♀. × 25.
,, 2. Dorsal surface, ♀. × 25.
,, 3. Ventral surface, ♂. × 16.
,, 4. Skin markings, dorsal surface, ♀.
,, 5. Palp, ♀. × 38.
,, 6. Genital area, ♀. × 55.
,, 7. Provisional genital area, nymph. × 55.

References.

1899. *S. lineatus* Sig Thor. En ny hydracnide-slegt og andre nye arter. Kristiania. Page 3, plate xviii, fig. 169 *a–b*.

The above is the original description with figure of genital area only.

1901. *S. lineatus.* Piersig in Das Tierreich, page 168.

Piersig here places it amongst the doubtful species.

1911. *S. lineatus* Walter. Hydracariness des nordschwedischen. Page 591, plate 8, fig. 6.

A supplementary description of this species from specimens found in Sweden. With one fig., the capitulum, only.

ON SOME ROTIFERA FROM SPITSBERGEN.

THE OXFORD UNIVERSITY EXPEDITION TO SPITSBERGEN, 1921.

REPORT No. 16.

By DAVID BRYCE.

(*Read June 13th, 1922.*)

FIGS. 1–6 IN TEXT.

HAVING already made a report (1) in 1897 on the Rotifera found in mosses collected by Dr. J. W. Gregory on the occasion of Sir W. Martin Conway's Expedition to Spitsbergen in 1896, I was interested to learn in the autumn of last year that a further series of mosses had been collected by the Oxford University Expedition, and I willingly undertook their examination, being curious to know if it would be possible from them to add to the information already possessed concerning the Rotifera which are able to live so far north. Since 1897 that information has been materially increased. There had been two previous records of Rotifera from Spitsbergen. In 1862 A. von Goes (3) recorded two species of Callidina, which he had found in some moss, but of which he had not determined the species. In 1869 Ehrenberg (2) examined some mosses, which had been collected in 1867, and in them found one rotifer, *Callidina alpium* (= *Pleuretra alpium*), and an "egg of a rotifer" unknown.

In my report of 1897 I was able to record the occurrence of 26 species, including the single species which had been seen by Ehrenberg.

Richard (9) in the following year recorded having found in Spitsbergen five species, all plankton forms.

In 1906 a large quantity of fresh moss was brought from Prince Charles Foreland by Dr. W. S. Bruce, having been collected by him during the stay there of the Scottish Spitsbergen Expedition of that year. This moss, along with some smaller quantities of older material from Franz Josef Land and Novaya Zembla, etc., was handed by Dr. Bruce to James Murray, at that time the well-known investigator of Scottish Rotifera. His report on the collection (5) was submitted to the Royal Physical Society of Edinburgh in the autumn of 1907. The Rotifera obtained from the Spitsbergen moss were dealt with separately, though at no great length. I find that of the 19 forms, which he observed, only 5 had been previously recorded by me, and one by Richard, and 13 species were accordingly additions to the Spitsbergen list.

In 1918 Olofsson published (8) an account of researches carried out in the summer of 1910, on the Crustacea and Rotifera observed and collected by himself in numerous lagoons and ponds throughout Spitsbergen and the various islands in the vicinity. All the Rotifera found by him belong to the order Ploïma, and make a considerable contribution to the list of that group, which was only poorly represented in the mosses examined by Murray and myself. Altogether Olofsson enumerates 34 species or well-marked varieties, including several described as new to science. Of the 34 forms 3 had been already seen by Richard, 2 by Murray, and 2 by myself.

In the mosses now reported on I have found 28 species or well-marked varieties. Of these 18 had previously been recorded; and 10 species remain as new records, bringing the total up to 81 species or well-marked varieties.

In considering the results of the three series of moss-gatherings, one cannot help remarking that in each the Bdelloid Rotifera have greatly preponderated, in the number of species obtained, over the Ploïma and Flosculariaceae. In the combined total of 51 species and varieties obtained from mosses, there are 35 Bdelloida, 15 Ploïma, and 1 Floscularian. This apparent disproportion is due to the fact that most of the Bdelloida are habitually moss-dwelling and are rarely or never found in pools or other waters. If collections had been made in the ordinary way from available pools or lagoons, the proportions of these groups would probably have been more than reversed, as has in fact been shown by Olofsson's results. It is not so much a question of temperature as of the customary habitat of the species. Where moss gatherings were made, it resulted that the Rotifera found were principally Bdelloida. A few species of Ploïma are also generally found in mosses. Apart from one Ploïmid which is not known to have been hitherto found in Europe, I find that among the 51 forms, 34 Bdelloida and 6 Ploïma are species which are rarely or never met with except where moss is present; while 1 Bdelloid, 8 Ploïma and 1 Floscularian are species almost invariably found in pools or deeper waters. The presence of these 10 species in the mosses examined is doubtless to some extent accidental.

At least 70 of the 81 forms enumerated in the full list given later have not only been already found in the more temperate countries of Europe, but are actually more or less common in Great Britain itself; among the species described as new there are no startling variations from already known European species. Thus, so far as they are yet known, the Rotifera of Spitsbergen furnish absolutely no evidence of local evolution. In this connection I may add that a very similar position is shown in the recently published report by Harring (4) on the general plankton collections made by the Southern party of the Canadian Arctic Expedition 1913–1918, which deals with pond or lake-dwelling rotifers only. These plankton collections, made, as I understand, in the north of Alaska, yielded in all 64 species of Rotifera, of which 5 are new to science. Of the remaining 59 species, no less than 50 are to be found in Great Britain and most of them are quite common forms. Although dealing for the most part with quite a different set of species, Harring's list tells much the same tale as does mine, viz. that these species from the far north are practically identical with those living in more temperate countries. It is the nature of the actual habitat, especially as regards the plenteous provision of suitable food, that is the predominant factor in the distribution of Rotifera, and temperature, if not too extreme, has only a secondary influence.

I think, however, that extremes of temperature may in some cases exercise a distinct influence upon the distribution of Rotifera, and that this is shown by Murray's (6) experiences in the Antarctic. Shortly after he had completed his report on Dr. Bruce's collections of mosses from Arctic territories, Murray became biologist to the British Antarctic Expedition, 1907–1909, and investigated the rotifer-fauna of the district near Cape Royds, where the expedition had its base for two summers and the intervening winter. His previous extensive knowledge of Rotifera, whether moss-dwelling or pool-dwelling, peculiarly fitted him for such an investigation. In the course of his researches he found rotifers both among mosses and in the lakes and ponds. In the former situation they were relatively scarce, while in the lakes they were extremely abundant in individuals, though the number of different species was comparatively small. From the mosses he was only able to obtain two species (one previously unknown), and from ponds and lakes only 14 species (including 4 new forms). I may point out that of these 14 species found in lakes, no less than 5 are species which are known in this country, but are never, or rarely, found in such habitats, while common enough in mosses. As these 5 species were not found in the Antarctic mosses, it may be inferred that the conditions of life in the lakes were more endurable than in the mosses; so much so that these 5 species have abandoned their customary habitat and adopted another of quite a different character, and that not sporadically, but en masse. A second instance of temperature or climatic influence upon the Antarctic Rotifera can be noted. Of the five species described by Murray as new to science, two without any doubt belong to Bdelloid genera whose other members, so far as yet known, are without exception oviparous. These two species, *Adineta grandis* Murray and *Philodina gregaria* Murray, are, on the contrary, viviparous. While other species of the same genera in the same habitat have retained the oviparous method of reproduction, these two species alone show this startling divergence from all known relatives of their respective genera.

The Antarctic list of 16 species of Rotifera resulting from the researches of such an experienced biologist as Murray, carried on for more than a year, compares very poorly with the Spitsbergen list of 81 species, of which 51 were obtained from a few mosses selected by non-expert hands. Two explanations may be suggested for the disparity, each perhaps partly responsible. Firstly, the extreme severity of the conditions of life near Cape Royds, which only a few species have succeeded in enduring. Secondly, the greater accessibility of Spitsbergen—its nearer proximity to countries affected by the beneficent Gulf Stream. I would add that moss-dwelling rotifers with their very exceptional powers of retaining vitality while apparently dust-dry, and with eggs of even greater endurance than the adult animal, would be much more likely to be distributed by wind-storms or by the agency of birds than would pool-dwelling species.

The hypothesis that the present Rotifera fauna of Spitsbergen has arisen from "accidental peopling" since the period of maximum glaciation seems to me feasible enough, and I do not seek any other solution of the problem of their presence, until some proof is forthcoming that animals having some definite relationship to Rotifera did exist there in still earlier ages.

The present series of mosses, collected in the months of July and August, 1921, had been in my hands for several weeks before I was free early in January last to commence their examination. I had scarcely started when I was forced to put on one side all microscopic work, and it was not until nearly the end of March that I was able to resume; most of the gatherings were examined in April and May. Although the period of eight or nine months between collection and examination was not excessive from the point of view of the possibility of reviving a large proportion of the Bdelloid Rotifera inhabiting the mosses, an earlier examination would possibly have enabled me to revive some few additional species.

As the examination proceeded it was impressed on me that either the larger species had greater endurance, or they had been better able to protect themselves against the dangers common to both large and small. I found that nearly every individual seen of the larger species, such as *Rotifer sordidus*, *Rotifer tardigradus*, *Macrotrachela habita* and *Mniobia russeola*, revived after a few hours' soaking of the moss, while a comparatively small proportion of the specimens of the smaller species showed the least trace of life. I think I am justified in stating also that the Bdelloid Rotifera showed on the whole a greater power of self-preservation than the eel-worms and water-bears associated with them and subjected to the like conditions.

Among the twenty-eight species found in these recent collections are two which have not hitherto come under my notice. One of these is a practically spineless variety of the widely distributed Bdelloid *Pleuretra Brycei*, a species whose type form is remarkable for a very characteristic row of spines crossing the back. Like most other spine-bearing species, it is subject to almost infinite variation in the number and exact disposition of the spines. I have not so far been able to find recorded any variety so nearly without spines as that now described.

The other form belongs undoubtedly to the Ploïmid genus Encentrum, one of the most interesting genera of the family of the Notommatidae. It was only after much search that I found that a form which agrees with it in the most important details had been found in the Antarctic and described and figured by Murray in the Report (6) already cited. As his study of the individuals seen was incomplete he did not name the species, but contented himself with assigning it to the genus Pleurotrocha. It is not included in the list of sixteen species recognised or named by him.

Mr. C. S. Elton, who personally collected the mosses examined, has furnished me with some particulars of the three localities where the various collections were made and of the actual positions of growth, and further, with the names of the mosses which have been identified by Mr. H. N. Dixon.

The latitude of all three localities is between 78° and 79° N.

Prince Charles Foreland: a long island off the west coast of West Spitsbergen. Freshwater Bay, where the collections were made, is on the N.E. side of the island. Here are steep mountains with a narrow coast-belt of flat, rocky or shingly ground; the mosses were from this region (raised beach by Point Carmichael) and from the foot-hills (Glen Mackenzie).

Mosses collected early July, 1921.

Z 1. *Rhacomitrium lanuginosum* Brid.
From bare and very dry shingle.

Z 2. *Hypnum uncinatum* Hedw.
Polytrichum alpinum L.
From sandy area, over shingle.

Z 3. *Dicranum groenlandicum* Brid.
Dry tundra.

Z 4. *Rhacomitrium canescens* Brid., var. *ericoides* B. & S.
From dry scree slope.

The five species of Rotifera obtained from these four gatherings were all present in the Z 1 collection, but in very small numbers, and I revived only isolated examples of the first two species. From Z 2 were revived three examples only of *Habrotrocha insignis*, but several dead specimens of *Pleuretra alpium* were also seen. In Z 3 and Z 4 I found only a few dead individuals, amongst which I could recognise two as being the var. *hirundinella* of *Macrotrachela plicata*. In these mosses I saw very few specimens of eel-worms, rhizopods, or tardigrades, and of these groups no single individual revived. The exceedingly poor results obtained from these gatherings are perhaps due to the bare positions from which they appear to have been taken.

Rotifers revived :

Habrotrocha insignis Bryce.
Mniobia russeola (Zelinka).

Not revived :

Pleuretra alpium (Ehrenberg).
Macrotrachela plicata (Bryce), var. *hirundinella* Murray.
Habrotrocha sp. (4-toothed, but not recognisable).

CAP BOHEMAN : a rocky point of land jutting out into Isfjord on the north side of the fjord. It is more or less flat and mostly sandstone rock. The pond from which the sphagnum was taken lay about ½ mile from the coast, less than 50 ft. above sea-level.

Mosses collected early July, 1921.

Sphagnum sp.
Cynodontium virens Hedw.
Hypnum brevifolium Lindb.
H. cordifolium Hedw.
From the bank of a pool.

As the sphagnum was dry when received, I had little expectation of securing any living specimens from it, but I took my earliest opportunity of washing a portion, *viz.* early in January. I found in it a very few dead rotifers, some dead tardigrades (and eggs) and several eel-worms. Three moss-mites, apparently of different species, had alone retained vitality. The ground moss I examined early in June, and found a few rotifers, mostly dead, those which revived representing the four species named below. One example of *Mniobia russeola* was infected by an endo-parasitic worm which is described later.

Rotifers revived :

Adineta vaga (Davis).
Rotifer sordidus (Western).

Mniobia russeola (Zelinka).
Habrotrocha sp. (not recognisable).

Klaas Billen Bay: a long fjord at the head of Isfjord in West Spitsbergen. Here also are mountains, and between them and the sea a strip of raised beach forms comparatively low, flat ground. The mosses were taken from a location in the neighbourhood of the small collection of huts known as "Bruce City," at the head of the bay.

Mosses collected early August, 1921.

L 1 and 2. *Hypnum vernicosum* Lindb.
H. stellatum Schreb.
L 3. *Cinclidium stygium* Sw.
L 4 and 5. *Orthothecium chryseum* Schwaegr.
Swartzia montana Lindb.
L 14. *Hypnum cordifolium* Hedw.
From pool with a fresh-water spring, moss mostly submerged.
L 16. *Orthothecium chryseum* Schwaegr.
Bryum pseudotriquetrum Schwaegr.
Swartzia montana Lindb.
The above from wet or damp edge of a shallow fresh-water lagoon.
L 17. *Camptothecium nitens* Schwaegr.
These from bank of same lagoon in comparatively dry situation.
L 18. *Bryum nitidulum* Lindb. (abnormal).
From edge of salt-marsh.
L 19. *Hypnum stellatum* Schreb.
Damp tundra.
L 21. *Hypnum scorpioides* L.
From very wet situation.
L 25. *Grimmia commutata* Huebn.
Dry tundra.

The mosses from Klaas Billen Bay furnished nearly all the species of Rotifera which are included in the present report.

From L 1 and 2 were obtained dead specimens of several species of ordinary pool-dwelling rotifers which were recognised from the more or less empty but distinctive loricae.

Monostyla cornuta (Müller).
Monostyla lunaris Ehrbg.
Mytilina ventralis brevispina (Ehrenberg).
Lepadella patella (Müller).

The following Bdelloids revived :

Macrotrachela habita (Bryce).
Macrotrachela Ehrenbergii (Janson).
Adineta vaga (Davis).
Adineta burbata Janson.

Dead specimens of a small species of Habrotrocha, quite unidentifiable, were numerous, and at least two other species did not revive. Many water-bears, eel-worms, and a few Cladocera were seen, but except one water-bear, all were hopelessly dead.

L 3 and 16. These gatherings proved less encouraging, as none of the animals which they had sheltered were revived. In L 16 were a few Rhizopod tests.

L 4 and 5. In these gatherings were found very few rotifers ; only three species revived :

Adineta gracilis Janson.
Macrotrachela multispinosa Thompson.
Habrotrocha constricta (Dujardin).

L 17. In addition to the first of these three species this moss produced :

Adineta barbata Janson.
Macrotrachela habita (Bryce).

L 14. In the washings from this moss, at least three species of rotifers could be distinguished, but as none of the specimens revived, none could be identified. There were also present a few eel-worms, many diatoms, and a multitude of water-bears, apparently of the genus Macrobiotus. When the moss had been soaked for two days, five water-bears were found to have revived.

L 18. In the washings from this gathering, I found no trace of Rotifera. Dead eel-worms were moderately numerous and some few diatoms were observed. The absence of rotifers was not surprising in view of the position whence the moss was taken.

L 19. Very few rotifers were seen in two carefully prepared washings; all were dead except a single example of:

Pleuretra Brycei (Weber).

L 19. From the damp tundra, two washings produced very few rotifers. Those revived were:

Adineta vaga (Davis).
Adineta barbata Janson.
Macrotrachela aculeata Milne.
Habrotrocha Milnei (= *Macrotrachela bidens* Milne).

L 21. This moss produced a better series of species and a fair proportion of living individuals after soaking for 2 to 3 hours; one dead Ploïmid was recognised as:

Monostyla cornuta (Müller).

The following Bdelloid species revived:

Ceratotrocha cornigera (Bryce).
Habrotrocha insignis Bryce.
Habrotrocha elegans (Milne).
Macrotrachela habita (Bryce).
Rotifer tardigradus Ehrenberg.
Philodina acuticornis Murray.
Pleuretra Brycei (Weber).
Adineta vaga (Davis).
Mniobia russeola (Zelinka).

There were also seen several Desmids, some Nostoc, several water-bears (of at least two species), several eel-worms, and a few Rhizopod tests. Several of the water-bears and eel-worms came back to active life.

L 25. This material consisted mainly of one large tuft or "slab" of close-growing ground-moss with tightly packed upright stems rather more than an inch high and perhaps the growth of several seasons. It proved to be by far the most productive for Rotifera, although the number of individuals seen was quite moderate. Many washings were made and the following species revived:

Adineta vaga (Davis).
Habrotrocha insignis Bryce.
Habrotrocha Milnei (= *Macrotrachela bidens* Milne).
Rotifer sordidus (Western).
Rotifer tardigradus Ehrenberg.
Habrotrocha constricta (Dujardin).
Macrotrachela papillosa Thompson.
Macrotrachela habita (Bryce).
Macrotrachela quadricornifera Milne.
Macrotrachela concinna (Bryce).
Macrotrachela aculeata Milne.
Philodina nemoralis Bryce.
Encentrum Murrayi sp. nov.

Since the reports on the earlier series of Spitsbergen mosses, etc., were published, the whole classification of the Class Rotifera has been subjected to most drastic revision and rearrangement. I have therefore thought it desirable in the following list of all the species of Rotifera which have been obtained from Spitsbergen up to the present, to employ the names now in use, but in all cases where these differ from the names given by the authors of earlier reports, to add the latter names within brackets.

SPITSBERGEN ROTIFERA.	Ehrenberg.	Gregory.	Richard.	Bruce.	Olofsson.	Oxf. Univ.
PLOÏMA.						
Proales sordida Gosse (= *Proales decipiens*) .		×				
Encentrum ferox (Western) (= *Diglena ferox*) .				×		
Encentrum Murrayi sp. nov.						×
Encentrum permolle (Gosse) (= *Diglena permollis*)		×				
Diaschiza gibba (Ehrenberg)					×	
Diaschiza gracilis (Ehrenberg) (= *Furcularia gracilis*)		×				
Diashicza sp. 1 incert.					×	
Diaschiza sp. 2 incert.					×	
Keratella quadrata (Müller) (= *Anuraea aculeata*)			×		×	
Notholca foliacea (Ehrenberg)					×	
Notholca foliacea latistyla Olofsson . . .					×	
Notholca longispina (Kellicott)			×	×		
Notholca striata (Müller) (= *Anuraea scapha*) .			×		×	
Notholca striata bipalium (Müller) (= *N. spinifera*)			×			
Notholca striata f. *extensa*					×	

SPITSBERGEN ROTIFERA	Ehrenberg.	Gregory.	Richard.	Bruce.	Olofsson.	Oxf. Univ.
PLOÏMA.						
Mytilina bicarinata (Perty) (= *Diplax bicarinata*)					×	
Mytilina mucronata (Müller)					×	
Mytilina ventralis brevispina (= *Mytilina brevispina*)					×	×
Euchlanis deflexa Gosse					×	
Euchlanis dilatata Ehrenberg					×	
Euchlanis oropha Gosse					×	
Lecane brevis (Murray) (= *Cathypna brevis*) .					×	
Lecane flexilis (Gosse)				×		
Lecane rotundata (Olofsson) (= *Cathypna rotundata*)					×	
Monostyla bulla Gosse				×		
Monostyla cornuta (Müller)				×	×	×
Monostyla lunaris (Ehrenberg)				×	×	×
Lepadella acuminata (Ehrenberg) . . .					×	
Lepadella ovalis (Müller) (= *Metopidia oblonga*)					×	
Lepadella patella (Müller) (= *Metopidia lepadella*)		×			×	×
Lepadella quadricarinata) (Stenroos) (= *Metopidia bicarinata*)					×	
Colurella adriatica Ehrenberg (= *Colurus caudatus*)		×			×	
Colurella colurus (Ehrenberg) (= *Colurella amblytelus*)					×	
Colurella obtusa (Gosse)					×	
Squatinella stylata (Milne) (= *Stephanops stylatus*)		×				
Squatinella tenella (Bryce) (= *Stephanops tenellus*)		×				
Scaridium longicaudum (Müller) . . .					×	
Lophocaris oxysternon (Gosse)					×	
Trichocerca cristata Harring (= *Rattulus carinatus*)					×	
Diurella bidens Lucks ? (= *D. cavia* Gosse) .					×	
Diurella longistyla Olofsson					×	
Diurella minuta Olofsson					×	
Diurella obtusidens Olofsson					×	
Diurella uncinata (Voigt)					×	
Polyarthra trigla Ehrenberg (= *P. platyptera*) .			×		×	
FLOSCULARIACEAE.						
Ptygura melicerta (Ehrenberg) (= *Œcistes serpentinus*)				×		
BDELLOIDA.						
Adineta barbata Janson		×				×
Adineta gracilis Janson		×				×
Adineta vaga (Davis)		×		×		×

SPITSBERGEN ROTIFERA.	Ehrenberg.	Gregory.	Richard.	Bruce.	Olofsson.	Oxf. Univ.
BDELLOIDA.						
Ceratotrocha cornigera (Bryce) (= *Callidina cornigera*)		×				×
Habrotrocha angusticollis (Murray) (= *Callidina angusticollis*)				×		
Habrotrocha aspera (Bryce) (= *Callidina aspera*)		×				
Habrotrocha bidens (Gosse) (= *Callidina bidens*)				×		
Habrotrocha constricta (Dujardin) (= *Callidina constricta*)		×				×
Habrotrocha elegans (Milne) (= *Callidina venusta*)		×				×
Habrotrocha insignis Bryce						×
Habrotrocha lata (Bryce) (= *Callidina lata*)		×				
Habrotrocha Milnei (= *Macrotrachela bidens* Milne)						×
Habrotrocha pusilla textrix (Bryce) (= *Callidina pusilla* var. *textrix*)		×				
Macrotrachela aculeata Milne						×
Macrotrachela concinna (Bryce)						×
Macrotrachela Ehrenbergii (Janson)						×
Macrotrachela habita (Bryce) (= *Callidina habita*)		×				×
Macrotrachela multispinosa Thompson						×
Macrotrachela musculosa Milne (= *Callidina musculosa*)		×				
Macrotrachela papillosa Thompson (= *Callidina papillosa*)		×		×		×
Macrotrachela plicata (Bryce) (= *Callidina plicata*)		×		×		
Macrotrachela plicata var. *hirundinella* (Murray) (= *Callidina plicata* var.)				×		×
Macrotrachela quadricornifera Milne						×
Rotifer sordidus (Western)						×
Roitfer tardigradus Ehrenberg (= *Rotifer tardus*)		×				×
Rotifer vulgaris Schrank				×		
Pleuretra alpium (Ehrenberg) (= *Callidina alpium* = *Philodina alpium*)	×	×		×		×
Pleuretra Brycei (Weber) (= *Philodina Brycei*)				×		×
Philodina acuticornis Murray (= *P. erythrophthalma*)		×				×
Philodina brevipes Murray				×		
Philodina nemoralis Bryce						×
Philodina rugosa Bryce (= *Philodina* sp.)		×				
Mniobia incrassata (Murray) (= *Callidina incrassata*)				×		
Mniobia russeola (Zelinka) (= *Callidina russeola*)		×		×		×
Mniobia tetraodon (Ehrenberg) (= *Callidina tetraodon*)		×				

Encentrum Murrayi sp. nov. (Figs. 1–3).

When fully extended and straightened, the body is moderately long and rather slender. It is divided by more or less obvious constrictions into some seven or eight segments. In lateral view the depth of the body is seen to be greater than its thickness. The dorsum is irregularly arched and swollen, but the exact outline is varied continually by incessant and violent contractions, or retractions of head or foot, as the animal swims vigorously about with many turnings and twistings.

The head is somewhat cylindric in form and has a rather low hood-like expansion on the dorsal front. The anterior portion is usually bent somewhat downwards and the hinder part hidden partly within the overlapping of the following segment, a distinct skinfold coming well forward on the head. The face is normally oblique but varies frequently to an almost prone position. The second and third segments have about the same thickness as the head, but the fourth segment containing the greater part of the stomach is notably arched and has generally behind it a moderate constriction. Then follows a less prominent but also swollen segment covering a large intestine. Behind this is a heavy skinfold crossing the body obliquely (in lateral view) and hiding the anus.

The foot has two joints, the upper having a very voluminous skin falling over and partly enveloping the lower joint. The latter, when seen fully outstretched (as in fig. 2), appears distinctly slender and tapering until near to the bases of the toes, where the skin seems tightly clinging. The length of this joint on the ventral side is about twice its depth, and this clearly distinguishes this species from *Encentrum permolle* and *E. ferox*. The toes had the remarkable peculiarity that in some examples they were nearly twice as long as in others. All the earliest specimens seen had the long toes, which in one case measured 48 μ in length, whilst most of the later had toes of about 25 μ long only, as in the example sketched (fig. 1). The toes were moderately stout and slightly decurved, the ventral edge nearly straight, the dorsal slightly convex, so that the toes tapered gradually from near their bases to the sharp tips. The bases were set close together, and the toes were strongly divergent.

The trophi (fig. 3) are of much the same type as those of

Encentrum ferox, *E. permolle*, *E. Hofsteni* and *E. Coëzi*. The rami are of semi-circular form, each terminating in two strong teeth, which I thought were jointed and capable of movement in an inward direction. The fulcrum is of moderate length, about as long as a ramus without the terminal teeth. In ventral view it appears slender, but seen laterally it has a breadth at

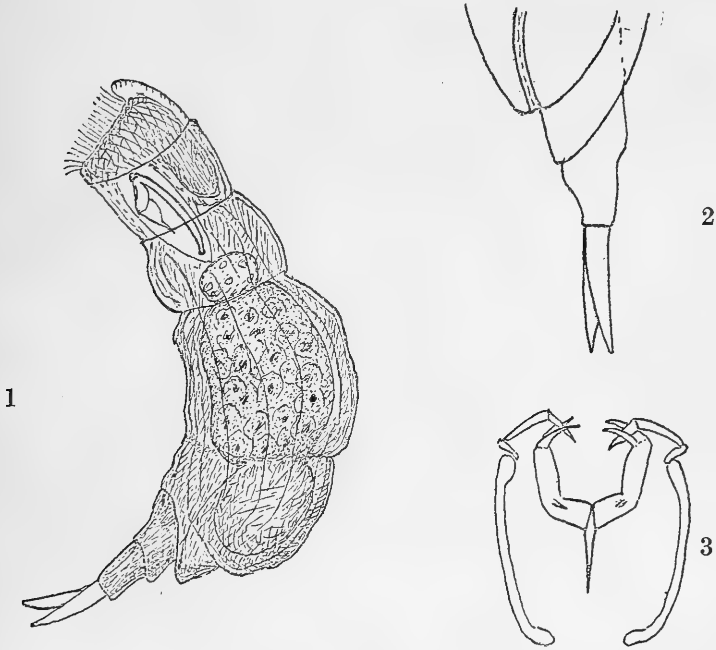


FIG. 1.—*Encentrum Murrayi*, sp. nov. Lateral view (swimming). × 280.
FIG. 2.—Posterior end of body, fullest extension. Lateral view. × 500.
FIG. 3.—Mastax. Ventral view. × 740.

the anterior part of about one-half its length. The breadth rapidly decreases towards its lower end. Each uncus seemed to me to have a terminal short tooth jointed to it and to be itself jointed to a long (about 33 μ) and moderately stout manubrium, which is posteriorly curved inwards and somewhat thickened and rounded at the hinder end. Between the uncus and the manubrium is interposed a small hardened piece, making in effect a double joint. The terminal tooth seemed, as well as I could make out, to be turned inwards and to pass between the two teeth of the ramus, as I have shown in sketch (drawn to scale from the last of three mastaces dissolved out by use of sodium hypochlorite solution). That three teeth were present appeared quite certain, but their relative position was very obscure, and I could not be sure that the single tooth belonged to the uncus and the paired teeth to the ramus, or vice versa. As my material was exhausted, I could not further investigate this detail. I was also unable to see definitely, first, whether the single tooth was hinged or connected in any way to the paired teeth, or had free and independent movement, and, second, whether it was always thrust between the paired teeth or whether it could also be moved forward beyond them.

In addition to the several parts figured, I saw in this last mastax two very slender rods, in length equal to about one-half the manubrium. Each seemed to be attached to one of the manubria near its junction with the uncus and to pass thence at about right angles towards the dorsum. I could not more definitely locate them. In the mastax of *Encentrum clastopis* (Gosse), Harring has seen slender L-shaped pharyngeal rods, attached to the incus near the joint of the uncus to the manubrium. These pharyngeal rods are possibly homologous with those of the mastax now described. As in many allied species, the trophi are exsertile and are frequently protruded when the animal is hunting about for its food. One individual which had lived for two days in a trough was found on the third day to have thrust forth the trophi so far that it could not get them back again, and as nothing could be done to help it, it very soon died. Both Milne and de Beauchamp have noted similar instances of dislocation in other species of the genus. I was unable to discern the brain, ovary or contractile vesicle. The latter two were probably obscured by the swollen stomach and intestine. No eyes were observed.

About a dozen living examples were obtained from washings of the "dry tundra" mosses (L 25). When dealt with, the moss was so dry as to be friable. This new form is therefore to be added to the very short list of Ploïmid species, which can protect themselves against desiccation. It is not known whether this protection is afforded by a varnish-like secretion by the alarmed rotifer as in the case of the Bdelloid species, but it seems probable that such is the case.

When swimming and hawking about in search of food, the example sketched most frequently presented a lateral view. It was rarely straightened, but mostly assumed the bent position figured, turning the lower part of the body nearly at right angles to the upper. The skin of the central body was apparently quite without rigidity and so loose as to appear baggy.

Length from 300 to 375 μ the variation being to some extent dependent upon the length of the toes.

Habitat.—Ground mosses.

In the Report on the Antarctic Rotifera already quoted, Murray (6) gives a figure and some few details of a large species of rotifer apparently having a close relationship to that now described, but not agreeing in every respect. As his observations were felt to be incomplete, he did not name his species but contented himself with assigning it to the genus Pleurotrocha. It would now be placed in the genus Encentrum. Notwithstanding several minor divergences in our respective descriptions, I think it probable that the Antarctic form is specifically identical with that now discovered in Spitsbergen moss. I give myself therefore the honour of associating the new species with the distinguished biologist of the Shackleton Expedition by naming it *Encentrum Murrayi.*

Mytilina ventralis brevispina (Ehrenberg).

Only isolated examples seen. The type form has been found in several lake and pond collections made by Mr. J. M. Jessup while serving on the Alaskan Boundary Survey (see Harring's report (4) already cited). It has also been found by Olofsson in Spitsbergen.

Monostyla lunaris (Ehrenberg).
Monostyla cornuta (Müller).
Lepadella patella (Müller).

Dead specimens of these three were found along with those of the first-named species. All are included by Harring in his list of Arctic species. *M. lunaris* is stated by him to be "abundant and widely distributed in the Arctic." All three species are recorded by Olofsson (8).

Adineta barbata Janson.
Adineta gracilis Janson.
Adineta vaga (Davis).

These three Adinetae are quite cosmopolitan. *A. vaga* occasionally occurs in pools, but, like the others, is a common inhabitant of mosses.

Ceratotrocha cornigera (Bryce).

Since the original discovery of isolated examples of this rather rare species in England, it has been found to be widely distributed. It has now been recorded from Scotland, Switzerland, Canada, Australia, and Peru.

Habrotrocha constricta (Dujardin).

One of the commonest of the pellet-making Philodinidae, and widely distributed.

Habrotrocha elegans (Milne).

In my earlier report (1), I described the specimens obtained from Dr. Gregory's collections under the name *Callidina venusta*, sp. nov. The species having since been transferred to the genus *Habrotrocha*, Milne's original specific name has again become valid and replaces *venusta*.

Habrotrocha insignis Bryce.

The few specimens which I have assigned to this species differed from the type form in showing very indistinctly the curious hardened plate in the head which I thought to be a stiffening for the upper lip, and which I have hitherto found to be somewhat conspicuous. In some examples I could detect no trace of it. Otherwise the specimens agreed with the British form.

Habrotrocha Milnei nom. nov. (fig. 5).

I take this opportunity to put forward a new name in place of one given earlier by Milne, when in 1886 he described a pellet-making rotifer closely allied to *Habrotrocha constricta* (Dujardin), but having only two teeth on each ramus, under the name of *Macrotrachela bidens*. In my revision of the classification of the Bdelloida (1910) * this species should have been assigned to the genus HABROTROCHA then created for the reception of all but the most aberrant of the pellet-making forms. But unfortunately the specific name *bidens* had been already employed for Gosse's still older *Callidina bidens*, which was also to be

* Bryce, D., On a New Classification of the Bdelloid Rotifera, *Journ. Q.M.C.*, 2nd Ser., vol. xi., pp. 61–92.

brought into the new genus, and Milne's species was dropped for the time.

I have occasionally found isolated examples which had only two teeth on each ramus, and which strongly resembled the familiar *Habrotrocha constricta* in other respects, differing only

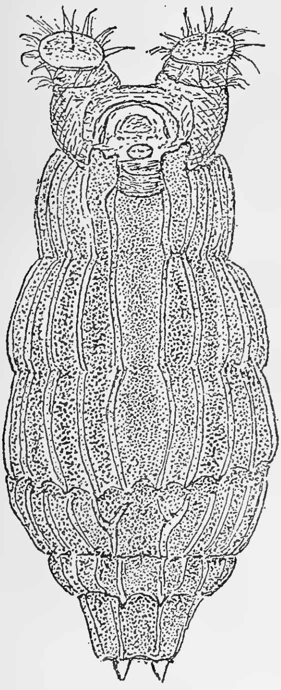


FIG. 4.—*Pleuretra Brycei* (Weber), var. Dorsal view, feeding position. × 500.

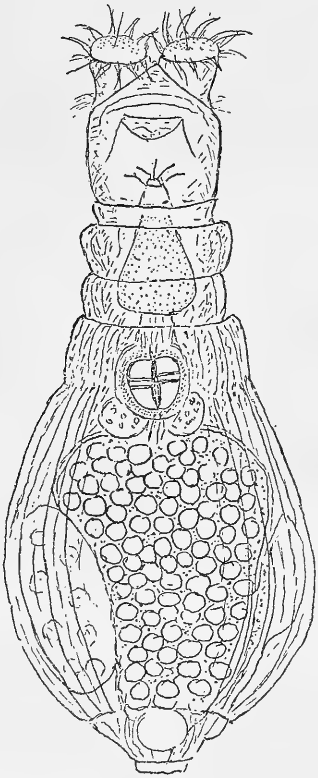


FIG. 5.—*Habrotrocha Milnei*, nom. nov. Dorsal view, feeding position. × 500.

in less important and not very obvious details, and I have felt no doubt that Milne's species was an absolutely valid form. I propose to name it after its discoverer, who was, I believe, the first zoologist in Britain to give attention to moss-dwelling Rotifera and by his earlier papers led the way to a very notable study which has completely revolutionised our knowledge of Bdelloid Rotifera.

The small trochi and the upper lip resemble those of *H. constricta*, and the general appearance when feeding is very similar. I think it is a rather smaller form than its commoner relative and rather more sturdy in build. The mastax and the brain are in the usual position, the rami have each two teeth, the upper lip is moderately high and centrally is obtusely pointed; the spurs are small cones set closely together, moderately divergent, but less so than in its relative.

The figure (fig. 5) is from an English example.

Length about 200 μ to 255 μ.

Habitat.—Ground moss.

Macrotrachela aculeata Milne.

Several examples of this species, which is exceedingly variable, were of the ordinary type found in Britain. It is a very widely distributed species, but occurs only in small numbers.

Macrotrachela Ehrenbergii (Janson).

Only recognised among the wet moss from the gatherings Z 1 and 2. Besides the adults, some of the characteristic spinous eggs were seen.

Macrotrachela concinna (Bryce).

Several specimens were seen in the washings from the "dry tundra" (L 25).

Macrotrachela habita (Bryce).

This species occurred in five different gatherings. It is one of the most widely distributed of moss-dwelling Bdelloida, and is extremely hardy. It is exceedingly variable in minor details. Murray has recorded its presence in the lakes near Cape Royds (6), where the local form was noteworthy for the deep crimson colour of the stomach. The Spitsbergen examples seemed typical in all respects.

Macrotrachela multispinosa Thompson.

Only one example of this most variable species was detected. It had the ordinary spines of medium length.

Macrotrachela papillosa Thompson.

I think only one example of this variable species was found, and in the "dry tundra" (Z 25). This form was also seen in the 1896 collections.

Macrotrachela plicata hirundinella (Murray).

Some dead specimens could be recognised as belonging to this variety. The distinctive processes were only of medium length. The type form was seen in the 1896 collections, but was not detected in the present series. Both the type form and this variety were seen by Murray (5).

Macrotrachela quadricornifera Milne.

A few specimens of this cosmopolitan species also occurred in the "dry tundra" (L 25).

Rotifer sordidus (*Western*).

The specimens seen of this variable species seemed to be all typical. They came from the ground moss from Cap Boheman and from the "dry tundra" from Klaas Billen Bay.

Rotifer tardigradus Ehrenberg.

The few specimens seen were all of the ordinary type, and call for no comment.

Pleuretra alpium Ehrenberg.

This species is noteworthy as the only rotifer recognised by Ehrenberg when in 1869 he examined some mosses which had been collected in Spitsbergen in 1867.

It occurred in the mosses which I examined in 1897. On the present occasion no single one of the few specimens seen showed any sign of life. Also seen by Murray (5).

Pleuretra Brycei (Weber), var. (fig. 4).

I found in the mosses from the gatherings L 19 and L 21 a practically spineless form which I have thought it worth while to figure in its customary feeding position, as no really satisfactory figure of this usually spinous and exceedingly variable species has yet been published. The type form has a transverse row of spines arising from the longitudinal skinfolds of the back, where these reach the rear of the third segment of the central body. At this point the skinfolds, which are rather stiff and strongly marked, are suddenly cut off and the ends of the ridges are produced into more or less short yet conspicuous thorn-like spines. The long row of 8 or 10 spines, crossing the back just below the middle, is frequently supplemented by a shorter row of 4 or 6 lesser spines on the hinder margin of the following segment and sometimes at least by two more spines on the next after that.

The anterior margin of the first central segment seems to be almost invariably furnished with a pair of rather solid-looking processes, frequently slightly furcate, which stand to right and left of a small medial dorsal sinus. In the variety now observed the processes just described were present though shorter and less furcate than usual; but the spines of the usual long row crossing the back were not developed. The skinfolds terminated in angular projections which could not be called spines. Two very short and blunt points seemed present to right and left of the central portion of the rear margin of the fifth central segment, but they could only be glimpsed occasionally. In other respects the specimens seemed normal. This species usually inhabits mosses growing in wet places and has proved to be very widely distributed, and very variable in the number and exact disposition of its spines. I do not think that a spineless form has yet been recorded, and in view of the great range of variation possessed by the species, I have not thought it desirable to separate these specimens as a new species. Some specimens approaching the type form were seen by Murray (5).

Philodina acuticornis Murray.

The specimens referred to in 1897 as *P. erythrophthalma* and of which I made some sketches at the time, did not belong to the species now regarded as the true *P. erythrophthalma* Ehrenberg. They seem rather to be indistinguishable from the species, a rather variable one, described by Murray some years later. Some specimens seen in the L 21 collection have also been assigned to the same species, which is one of the most puzzling in the genus, and one of the most widely distributed.

Philodina nemoralis Bryce.

A few specimens of this moss-dwelling species, rarely found in ponds, were present in the "dry tundra" (L 25). In some mosses brought to me from the Faroë Islands by Mr. Earland some years ago I found numerous examples of this easily recognisable species.

Philodina rugosa Bryce.

To this species are to be assigned some rough-skinned Philodinae referred to in my report of 1897 as *Philodina* sp.

Mniobia russeola (Zelinka) (fig. 6 *a–d*).

This large and handsome rotifer, which occurred in the gatherings of 1896 and was also seen by Murray (5), was present in three collections, one from each of the three localities whence moss was taken. Its presence proved specially interesting. The solitary example seen in the washing of the Z 1 gathering was found, on being isolated, to have within its body a vermiform parasite, which was recognised as one which I had seen on two previous occasions in British specimens of the same rotifer. At a later date another individual from the L 21 moss was found to be infected by the same parasite, and from this latter were obtained some details which I had not been able to make out on previous occasions.

Mniobia russeola is a rather stoutly built Bdelloid rotifer whose body when fully extended is somewhat larviform, and divided into fifteen segments, the anterior six forming the head and neck, the following six the trunk (or central body), and the last three a very short foot. Adult individuals are usually at least 600 μ in length, and I have seen them up to nearly 800 ft. long. The skin is transparent. When the animal feeds it usually assumes a somewhat squatting position. When undisturbed it will often continue quietly feeding for hours with scarcely any change of position. In the genus Mniobia, as in most of the other Bdelloid genera, the stomach is a long sausage-like organ occupying a large proportion of the cavity of the trunk. It has a thick wall consisting of more or less minutely granular tissue packed between two membranes or tubes, one within the other, the inner lining forming cavity of the stomach, the outer the actual lumen or the exterior coat of this organ. Behind the stomach and usually separated by a constriction controlled by a sphincter muscle, is a short bladder-like intestine. Behind the intestine is a contractile cloaca, which combines the functions of a contractile vesicle (as found in Rotifera other than Bdelloida), and of a cloacal passage leading to the anus.

When I detected the parasite in the *M. russeola* from the Z 1

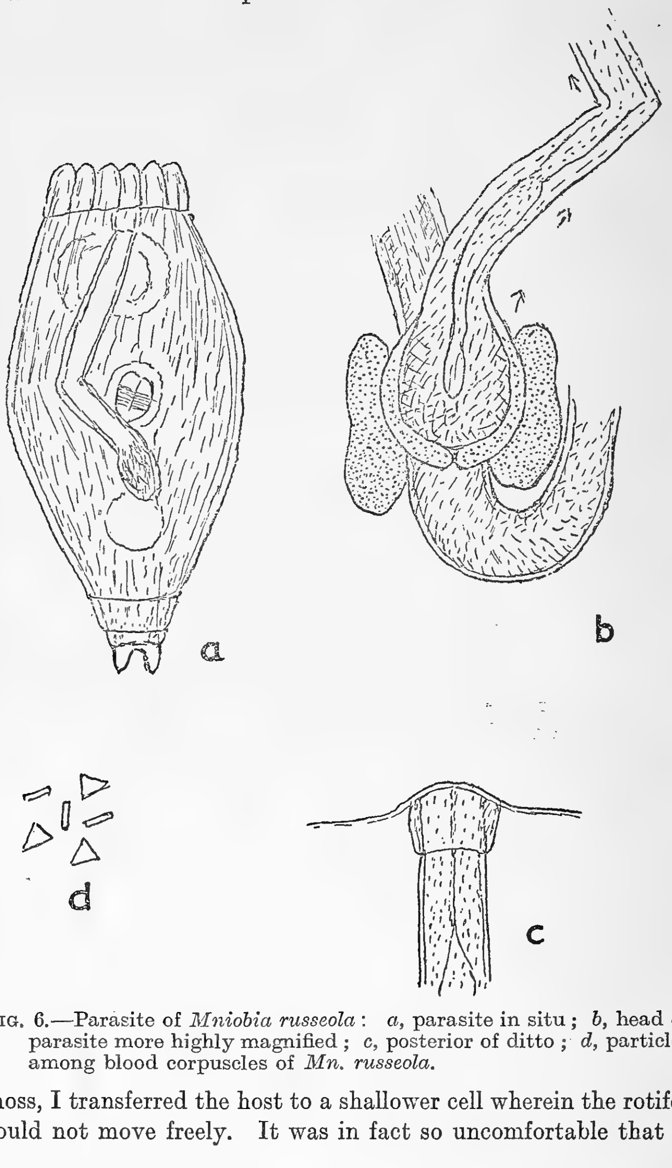


Fig. 6.—Parasite of *Mniobia russeola*: *a*, parasite in situ; *b*, head of parasite more highly magnified; *c*, posterior of ditto; *d*, particles among blood corpuscles of *Mn. russeola.*

moss, I transferred the host to a shallower cell wherein the rotifer could not move freely. It was in fact so uncomfortable that it did not resume feeding but contracted into the position shown (fig. 6 *a*) wherein the head and neck are retracted within the central body. (The internal organs of the rotifer are omitted or barely indicated, so that the position taken by the parasite may be more clearly understood.) This position of the parasite has been approximately identical on all four occasions. The parasite is shown with its head resting upon or gripping in some way the lower part of the stomach near its junction with the intestine (see also fig. 6 *b* drawn from the second Spitsbergen example). Behind the head of the parasite follows a long tubular body, which passes nearly to the side of the rotifer and then abruptly changing its course passes forward to the anterior dorsal margin of the seventh segment of the rotifer (i.e. of the first central segment), almost in the median line. Thus the parasite has its posterior extremity well forward in the rotifer, while its head is far to the rear. I was able to make out a terminal and somewhat thickened segment (fig. 6 *c*). At the point stated above, the skin of the rotifer seemed to be pushed upwards and outwards in a gentle swelling (fig. 6 *c*). I had proof later that at this point the parasite maintained its communication with the exterior of the rotifer, and it is suggested that it is probably also the point where the parasite had gained admission to its victim's body, penetrating through the softer integument of the invaginated skin between the sixth and seventh segments of the body of the rotifer. So far as I could make out, the parasite seemed by sucking with its head or mouth to be swallowing fluid drawn from between the two membranes of the stomach wall of the rotifer. At intervals of from 30 to 60 seconds, occasionally even more, the long central body of the parasite gradually distended and then suddenly collapsed, becoming only discernible with difficulty, but presently coming gradually into view again as a long bladder apparently containing fluid only. The collapse although nearly instantaneous in its action throughout almost the whole length of the central portion of the parasite was not quite so. I noticed that the movement began near the head, and that the muscular impulse involved, whatever be its exact nature, travelled from the head backwards to near the posterior segment. While the tube was being distended the portion immediately before the terminal segment was apparently unaffected, but I succeeded in seeing that when the collapse of the tube occurred, this portion was momentarily distended. These more intimate details were being obtained from my second example (whose host, after isolation, I had left in greater freedom and which was steadily feeding all the time), when a movement in the rotifer attracted my eye, and I then glimpsed some particles passing quite rapidly through the distended tube of the parasite. I had scarcely realised what was happening when the particles were ejected into the water outside the rotifer, issuing from the point where I had located the posterior extremity of the parasite. The particles seemed to me, as they floated in the water, to be portions of the granular tissue lying between the two membranes of the wall of the stomach of the rotifer.

At each side of the head of the parasite I could see an elongated body suggesting a gland, with minutely granular contents. These external bodies seemed undoubtedly to belong to the parasite. Their contents seemed to be moved occasionally by some pressure as they changed position. I also observed some slight independent movement in the anterior part of the head of the parasite. As a general rule the head did not change its position, but now and again I saw a slight movement as though it was altering its hold.

What I could make out of its head will be best understood from fig. 6 *b*, where it is shown *in situ* on the exterior of the stomach of its host. It seemed to have an external definable integument, which in front was not continuous, but as though there was there some opening. Within the integument was what I took to be mainly a muscular structure with a small central cavity communicating with the distensible tube behind. The lateral gland-like bodies I have already described.

I estimated the length of the second parasite as about 300 μ if straightened out.

When I examined the host it was evident that, although feeding without cessation, it was not in a normal condition. The last two segments of the central body, known as the lumbar (or preanal and anal) segments, were unusually distended and the organs there located could not be defined. The contractile cloaca, which normally fills and empties itself every minute or so, was not acting at all. The inference was that the parasite was drawing and expelling so much fluid from the rotifer that there was none left for the contractile cloaca to deal with.

A day later the rotifer was distinctly weakened, and as I was temporarily leaving home I essayed to make a preparation showing the parasite *in situ*, but did not get a satisfactory result.

The parasite may be shortly described as an animal apparently belonging to the Vermes, having a distinct head, a long tube-like unsegmented central body and a distinct terminal segment. Whether it is identical with any form already known has not yet been ascertained. All internal parasites hitherto recorded for rotifera have been either very minute protozoa, algae, amoebae, or bacteria. This form is very much larger than any of these, and of much more specialised structure. It had previously been seen by me in a specimen of the same rotifer from Perranporth (Cornwall) and in another from Killin (Perthshire). The host is almost exclusively an inhabitant of ground mosses and is a very hardy and long-lived species, usually of distinctly reddish-yellow colour.

This second infected individual from Spitsbergen had another very interesting abnormality which may or may not be connected with the presence of the parasite.

In this species and in one or two other large forms, the fluid of the body cavity contains numerous very fine particles which have been regarded as blood corpuscles. In this individual I observed among such particles some larger particles, about a dozen in all, which, like the small, were driven hither and thither by every change of position of the rotifer. Of these larger particles some seemed longer than broad, others appeared triangular in form. I presently found that the former were identical with the latter, and simply represented their lateral aspect. The triangular forms were accordingly flattened tablets, each side about 5–6 μ long, with approximately equal angles (fig. 6 *d*).

Tardigrada.

Although water-bears were found in several gatherings of moss, only a very few individuals were revived, representing two distinct species. One of these was a Macrobiotus, which I did not attempt to identify more closely. The second proved to be *Echiniscus Spitsbergensis* Scourfield, a species first discovered in the mosses brought from Spitsbergen by Dr. J. W. Gregory in 1896. In the individual which I compared with Scourfield's (10) figure and description, the posterior processes were distinctly more developed. Murray (7) has recorded this species from Loch Morar in Scotland.

It is my duty to express my grateful thanks to Mr. C. S. Elton for much help in the preparation of this report.

The following works are specially referred to by figures in brackets, after the names of authors, etc. :

(1) BRYCE, DAVID : Contributions to the Non-Marine Fauna of Spitsbergen. Part II, Report on the Rotifera, *Proc. Zool. Soc. London*, 1897, pp. 793–799.

(2) EHRENBERG, C. G. : Das unsichtbar wirkende Leben der Nordpolarzone. *Die Zweite Deutsche Nordpolarfahrt in den Jahren* 1869 *und* 1870, Band II, Leipzig, 1874.

(3) GOES, A. VON : Om Tardigrader Anguillulae m.m. frän Spetsbergen, *Ofvers. K. Vet., Akad. Förh.* 1862, p. 18.

(4) HARRING, H. K. : *Report of the Canadian Arctic Expedition* 1913–1918, vol. viii, Part E, Rotatoria. Ottawa, 1921.

(5) MURRAY, JAMES : Arctic Rotifers collected by Dr. William S. Bruce, *Proc. Roy. Phys. Soc. Edin.*, vol. xvii, pp. 121–127. Edinburgh, 1908.

(6) MURRAY, JAMES : Antarctic Rotifera—Brit. Antarctic Expd. 1907–1909, *Rep. Sci. Inv.*, vol. i, pp. 41–65. 1910.

(7) MURRAY, JAMES : The Tardigrada of the Scottish Lochs, *Trans. Roy. Soc. Edin.*, vol. xli, part iii, pp. 677–698. Edinburgh, 1905.

(8) OLOFSSON, OSSIAN : Studien über die Süsswasserfauna Spitsbergens. Beitrag zur Systematik, Biologie und Tiergeographie der Crustaceen und Rotatorien, *Zoologiska Bidrag frän Uppsala*, Band VI, Uppsala, 1918, pp. 183–634.

(9) RICHARD, J. : Sur la faune des eaux douces explorées en 1898 pendant la campagne du yacht *Princesse Alice* (Lofoten, Spitsberg, Iles Beeren, Hope, de Barents et Faeroer), *Mem. Soc. Zool. France*, vol. xi, Paris, 1898, pp. 326–338.

(10) SCOURFIELD, D. J. : Contributions to the Non-Marine Fauna of Spitsbergen. Part I, Preliminary Notes, and Reports on the Rhizopoda, Tardigrada, Entomostraca, etc., *Proc. Zool. Soc. London*, 1897, pp. 784–792.

NOTICE OF BOOK.

Modern Microscopy : A Handbook for Beginners and Students. By M. I. Cross and Martin J. Cole. Fifth edition, revised and rearranged by Herbert F. Angus. Demy 8vo, pp. x + 315, 12 plates, 144 figures. London: Baillière, Tindall & Cox, 1922. 10*s*. 6*d*. net.

The authors stated in the preface to the first edition of *Modern Microscopy*: " This handbook is not intended to be an exhaustive treatise on the microscope—but to afford such information and advice as will assist the novice in choosing his microscope and accessories and direct him in his initial acquaintance with the way to use it." That this intention has been fulfilled is indicated by the appearance of a fifth edition. The authors have availed themselves of this opportunity to revise and rearrange the text, making several additions of importance. For this purpose they have obtained the able assistance of Mr. H. F. Angus, who has entirely rewritten the first part of the book in order to bring it into line with present-day knowledge and methods. This part has been somewhat curtailed as compared with former editions in order to increase the space devoted to Parts II and III, but as nothing essential for the beginner to know has been omitted this proves a distinct advantage. As appendices to this part we have a Glossary of Technical Terms, details of the Standard Gauges R.M.S., and the specifications for three types of instrument as suggested by the British Science Guild some few years since.

The papers of a technical character forming Parts II and III have always been a distinctive feature in the later editions of this book, and several very interesting additions have been made. These papers deal either with the application of the microscope to technological research or to the study of special groups of animals and plants. In selecting one for special mention we would draw attention to the particularly interesting account by D. Ward Cutter of " The Microscope in Agriculture," dealing with the micro-organisms of the soil and the results of experimental research into their influence on soil-fertility. Here the author, as an addendum, gives a list of books dealing with the subject. This example might be very usefully followed by the other authors when the opportunity arises for another edition.

We congratulate the authors on the appearance of this edition, and the improvements which they have been able to introduce.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the 563rd Ordinary Meeting of the Club, held on October 11th, 1921, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on June 14th, 1921, were read and confirmed.

Messrs. J. Adam Guthrie, Ed. Montague Hardy and D. Sydney Martin were balloted for and duly elected members of the Club. Twelve nominations were read for the first time.

The President announced that Dr. E. Pénard had presented to the Club a copy of his book, *Études sur les Infusoires d'eau douce.* A vote of thanks was accorded to Dr. Pénard for his valuable donation. The Hon Secretary distributed to the members a programme of the chief papers for the meetings till the end of the year. Mr. F. Addey would read a paper on " Pinus sylvestris " on November 8th, and Mr. T. E. Wallis would give a lecture on December 13th on " Microscopy as an Aid to Analysis." A list of apparatus for sale that had belonged to the late Dr. Spitta was also distributed, and a note read from Mr. Pearsall stating that he could supply tubes of plankton from the English lakes. Mr. Earland very kindly brought for distribution a supply of foraminiferous material. Mr. N. E. Brown exhibited some specimens and drawings of the South African species of Hydrodictyon (Water-net), which had been found in 1912, but not again until this year. The Hon. Secretary read a note by Mr. E. M. Nelson describing a polariscope which was a modification of one made by Mr. Wood. The polariscope consists practically of two bundles of glass plates and a mirror. The light enters and leaves the apparatus in the same line, so that the polariscope may be easily rotated. Two bundles each of eight glass plates are set at the polarising angle so that the light is reflected from one bundle down to a silvered mirror, then up again to the other bundle and out of the apparatus. In this way it is possible to make a very practical polariscope which will completely fill the back lens of a large substage condenser. By loosening two screws the cover can be taken off and the glass plates removed for purposes of cleaning, without disturbing the adjustment of the instrument. Mr. F. Addey, in a note on the measurement of the vertical dimensions of objects, explained how it is that, in measuring the depth of a microscopic object by means of the fine adjustment, the apparent depth should be multiplied by the refractive index of the medium in which the object measured is immersed.

Mr. A. Earland was then called upon to give his lecture on "Deep Sea Deposits." Mr. Earland began by emphasising the importance of the infinitely little in nature. The extinction of the elephant would make little difference to the economy of the world, while the extinction of a small animal like the rat would have far-reaching effects. We should lose a valuable scavenger, a great destroyer of foodstuffs, and the carrier of plague. In the sea it is much the same, and has been so all through geological times: the whales and fishes, though of great economic value to man, are less important than the organisms upon which they feed, and these again depend for their food on micro-organisms. Some of the micro-organisms belong to geologically ancient types; there are, for instance, Silurian *Lagenae* which have persisted until the present day. One of the greatest differences between the conditions under which life exists on land and in the sea is the absence of light in the sea. Except under certain very favourable conditions it is practically dark at 50 fathoms, and at 500 fathoms there is nothing but a very little ultra-violet light. All animals feed on vegetables—either directly, or indirectly as in the case of the carnivora, which feed on herbivorous animals. Vegetable life cannot continue without light, and therefore at a depth of 50 or 60 fathoms it practically ceases to exist. Animals, however, are found even in the deepest parts of the ocean, and the question arises as to how such animals find food. The answer to this question is "cold storage." At a depth of 1,200 to 2,000 fathoms the temperature is fairly constant at about 35° F. There are practically no bacteria in the deep sea, and consequently no putrescence, so that the vegetable life of the surface waters after death sinks to the bottom and becomes food for fixed animals. Haeckel divided the creatures that live in the ocean into three sections: (1) Benthos, or the creatures that live on the bottom, such as flat fishes, star fishes, etc.; (2) Nekton, or free-swimmers; and (3) Plankton, or drifters. The last section, which consists largely of algae and protista, is the most important. The plankton lives principally in the surface water to the depth where light ceases, but dies in the mid-waters of the ocean. The problem of the distribution of plankton has been solved by the use of the tow-net. Mr. Earland showed samples of tow-nettings taken under various conditions of depth, etc., and described the nets used by means of diagrams on the screen.

Mr. Earland then described how the depth of the sea increases as the distance from the land, making special reference to the North Sea. The bottom slopes gradually away from the shore-line to a depth of about 100 fathoms and until it reaches the edge of the "Continental shelf," which marks the original shore-line of the ancient continent before denudation of the earth's surface began to raise the surface of the seas. Hereabouts lies Murray's "mud line," at which limit the finest material denuded from the land comes to settlement, furnishing an abundant supply of food to the varied forms of marine life which congregate about this depth. At Murray's line such forms as foraminifera are found at their best. No purely terrigenous deposits occur outside the Continental shelf, which in this corner of Europe lies to the north of the Shetland Islands. From the Continental shelf the "Continental slope" drops sharply down to the "abyssal plain." To oceanographers any part of the ocean beyond 3,000 fathoms is known as a "deep." The North Sea, no part of which is deep enough entirely to submerge St. Paul's Cathedral, is shallow water. The deepest sounding so far discovered in the ocean is in the "Swire" deep, off the Philippine Islands, 5,364 fathoms—nearly a mile deeper than Mount Everest is high. The pressure at such a depth is 960 atmospheres, or 6·4 tons to the square inch. The organisms that live at great depths in the sea are not affected by the pressure so long as they remain at about the same depth. If they are brought up to the surface the results are disastrous, fishes being burst open or their internal organs forced out by the great alteration in pressure. The speaker had seen a fir pole that had been sent down to 1,000 fathoms come up swollen to double its original size, owing to the compression and subsequent expansion of its cellular tissues. An iron socket which had been tightly fitted on to its end had fallen off during its descent owing to the compression of the wood.

Deep-sea deposits consist mainly of the organic remains of three groups—Foraminifera, Radiolaria, and Diatoms. Deep-sea deposits, as opposed to "terrigenous" deposits, depend for their formation on the existence of pelagic organisms having both calcareous and siliceous shells. After death, and even during life, these organisms slowly sink into the depths, the calcareous matter of the dead shells being slowly dissolved by the sea water as they sink. The organisms are of varying sizes, and the carbonate of lime with which many of their shells are constructed is no doubt more readily soluble in some organisms than in others. Hence the calcareous shells of the *Pteropoda*, which, owing to their large size, more or less mask the smaller shells of the *Globigerinidae* and other pelagic foraminifera, are the most conspicuous feature of shallow-water oozes (300-700 fathoms), and the material is known as pteropod ooze. Before the 1,000-fathom line is reached, the pteropod shells have practically disappeared by solution, whereas the *Globigerinidae*, which are more resistant to solution, and also are capable of maintaining existence while sinking and of continuing existence on the sea bottom at great depths, come into prominence, and we call the material a globigerina ooze. The long, fine spines with which living globigerina are beset dissolve before they reach the bottom. But the term globigerina ooze is a very elastic one. It covers any deep-sea deposit in which *Globigerinae* predominate, and the calcareous contents may vary from 90 per cent. to 20 per cent. of the whole, the highest percentage being reached in tropical oozes between 1,500 and 2,000 fathoms. Beyond 2,000 fathoms the calcium carbonate rapidly decreases, and the ooze passes gradually into red clay, the deposit which covers all the great depths, and which, as a general rule, may be said to begin at about 2,500 fathoms. In red clay, which is merely the residuum of ooze after decalcification, the calcareous constituents are always below 20 per cent. of the mass, and in great depths it is practically devoid of calcareous constituents. Local conditions, proximity to land, salinity and surface temperature are all governing factors which influence the nature of a bottom deposit at particular depths. As a general rule, solution of calcium carbonate proceeds more slowly in the Atlantic than in the Pacific, hence globigerina ooze is found at greater depths in the Atlantic than in the Pacific; but such oozes from great depths are hardly separable from red clay. It must not be thought that deep-sea deposits are of a fixed and constant nature, or that it is possible to draw a sharp line anywhere and say that globigerina ooze begins or ceases at that line.

Radiolarian oozes, which are siliceous, occur at depths beyond the limit at which calcareous organisms disappear by solution, but only in the Pacific and Indian Oceans in water of high temperature and salinity and at a great distance from land. Pure Diatomaceous oozes occur only in the Antarctic, in water of low salinity and at a distance from land.

A large number of beautiful lantern slides—chiefly of Foraminifera—were shown on the screen and described, and the meeting closed with a very hearty vote of thanks to Mr. Earland for his interesting address.

At the 564th Ordinary Meeting of the Club, held on November 8th, 1921, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on October 11th, 1921, were read and confirmed.

Messrs. Harry Alfred Barker, Frederick Adams, Percy A. Aubin, F.R.M.S., H. Ayscough Thompson, Charles Fred. Williams, R. Elliott Griffiths, Horace Crosby Cork, H. J. Falkner, Alfred G. Bullivant, W. Thomas Watkin-Brown, Oliver Latham and Miss Annie Dixon were balloted for and duly elected members of the Club. Six nominations were read for the first time.

The President announced that in future smoking would be permitted at the close of the ordinary meetings and after 8.30 p.m. at the gossip meetings. The Hon. Secretary announced that the usual journals had been received in exchange by the Librarian, and that two books had been presented to the library by Mr. A. W. Sheppard. He reminded the members that the paper for December 13th was by Mr. T. E. Wallis on "Microscopy as an Aid to Analysis," and stated that he had received a communication from a member (Mr. W. M. Bale) in New South Wales on mounting in gum sandarac. This paper would also be read, so that Mr. Wallis, who had advocated the use of this medium, would have an opportunity of commenting on it. The Hon. Secretary also announced that the following papers would be read: On January 10th, "Mosquito Investigation," by Dr. C. Tierney;

on February 14th (annual meeting), President's address; on March 14th, "Mounting in Glycerin with Wax Seals, with special reference to Entomostraca," by Mr. B. S. Curwen. The President announced that two old members of the Club had died since the last meeting. Mr. Nelson had written to say that Mr. F. Hughes, of Reigate, had died, and the other deceased member was Mr. C. F. Rousselet. The President read a short biographical note by Mr. Sheppard. Mr. Rousselet was very well known to most of the members of the Club. He was born in 1854 and belonged to a Huguenot family. He came to London in 1873 and joined the Club in 1883. Mr. Bryce also said that he had known Mr. Rousselet for many years. Before 1886 our knowledge of the Rotifera was very limited. A small band of workers then devoted themselves to the study of the group. Mr. Bryce worked at the Bdelloid Rotifera and Rousselet looked after the rest. Rousselet was the authority on the Rotifera for the whole world; he had the valuable assistance of Mr. Dixon-Nuttall, and their joint papers have contributed much to the value of Q.M.C. *Journal*. Personally, said Mr. Bryce, Mr. Rousselet was always agreeable and pleasant, and always ready to give information. The Club had sustained a great loss. A vote of condolence was passed in the usual way.

The President exhibited an ivy shoot from Florence bearing a curious cup-shaped leaf. Dr. Rendle said that it was one of the commonest malformations of leaves and was of interest in suggesting how the pitchers of the pitcher plants may have arisen.

A short paper by Mr. Nelson on "Polarisation: Rings in Quartz and N.A." was read by the Hon. Secretary. Mr. Nelson said that the rings shown by a thin piece of quartz were given off at such a wide angle that perhaps only one could be grasped by a wide-angled objective. If the quartz was thicker the rings were closer together, and it had been suggested that they might be used for measuring the N.A. of objectives. This, however, was not possible, as the rings were not at equal intervals of N.A. apart. A table was given compiled from the measurements of more than 60 objectives, showing the number of rings visible with various numerical apertures, and showing that equal increments of N.A. require an increasing difference in the number of rings. Several semi-apochromats, apparently constructed upon similar formulae, were found to show more rings than they ought to from theoretical considerations. The reason for this peculiarity has not been discovered.

The Hon Secretary then read a note by Mr. H. Wood on "A New Polariser of Large Field." The polariser, which was exhibited and described, was the result of the development by Mr. Wood of a suggestion of Mr. Nelson's. The apparatus consists of a tube 4 in. long, having at each end a plano-convex lens, convex side outwards, of $1\frac{1}{4}$ in. diameter and 2 in. focal length. (Mr. Nelson suggests using the lenses from an old binocular.) A $\frac{1}{2}$-in. nicol is fixed in the middle of the tube, and at each end of the nicol is a diaphragm as large as its aperture will allow. Between each diaphragm and the plano-convex lens at the corresponding end of the tube is placed (near to the diaphragm) a double concave lens. The light from the lamp is parallelised and then passes through the polariser, which can be rotated, to the mirror. The effect of the lens is to send the light through the nicol in a direction parallel to its axis. The polariser was exhibited, yielding a field equal to the back lens of a full-sized Abbe condenser.

Mr. F. Addey was then called upon to give his lecture on "Pinus sylvestris." A few years ago Mr. Addey had spent a summer working at *P. sylvestris* (the Scotch fir), and he proposed to describe its structure and method of reproduction so far as he had seen it, illustrating his lecture by the photographs he had taken of the tree and of the sections he had made of various parts of it. If the end of a branch of *P. sylvestris* be examined in autumn it will be found that there is a large terminal, resin-covered bud, surrounded by several other large resinous buds, in between the scale leaves with which the end of the branch is covered. Lower down the long shoot which terminates the branch are numerous short shoots, each bearing two acicular foliage leaves. In the spring the terminal bud lengthens, forming another long shoot, and the lateral buds form a whorl of long shoots. Each year this process is repeated, the distance between one whorl of branches and the next roughly representing one year's growth. The result of this method of growth is a long straight stem with lateral branches, the outline of the tree being pyramidal. The leaves persist for only two years, and the lower branches soon begin to drop off, so that the tree loses its symmetry. A series of photographs of sections of the stem was then shown, and the structure explained. If a transverse section of a young elongated shoot be made in June, the following structures will be noted. The stem being grooved, the section has a wavy outline; there is a well-marked cuticle, an epidermis consisting of a single layer of thick-walled cells; next a layer of cortical tisue, in which large resin passages occur lined with resin-secreting epithelium. There is a layer of cork and a cork cambium near the periphery of the cortex, and the pith is surrounded by a ring of vascular tissue. The structure was described in detail, and the development of the stem illustrated by sections made at different periods of growth. There are no vessels, water being conducted by means of the long pointed tracheides, which communicate with each other by means of bordered pits. The mechanism of the bordered pits was shown by photographs and drawings.

Mr. Addey then proceeded to describe the leaf, which is needle-shaped and so constructed as to restrict the loss of water by evaporation, the cuticle being thick and the guard cells of the stomata being sunk below the surface, leaving a pit, which becomes filled with air saturated with water vapour. On the long shoots, and especially low down on the tree early in June, the small yellow male cones are found. The female cones occur on the upper part of the tree, and as they are wind-fertilised the pollen must be carried up. In order that pollination may be readily effected, the pollen grains are provided with wings, usually filled with air, to make them more easily carried by the wind, and are produced in great quantities. The female cones are first observed as small green cones near the apices of the long shoots; the scales open to receive the pollen, and the next year the cone has grown larger. It is not until the third year that the cone, which has become brown and lignified, opens to permit the ripe seeds to escape. The whole process of fertilisation, development, and germination of the seeds was fully illustrated and described. Mr. Addey said that he had found the working out of the structure and life-history of one plant of great interest, and that he had derived much more pleasure from it than from more diffuse efforts.

Mr. Wycherley (Hon. Secretary) exhibited a series of drawings in coloured inks of sections, etc., of *P. sylvestris* showing the histological structure by differential staining.

The President said that in pines we first find obvious adaptation to life on land, although there is a striking resemblance to the ferns in the method of reproduction. In some older gymnosperms the aquatic method of pollination still obtains. The resin canals vary in number and position in different species, and identification is almost possible by the examination of a transverse section of the leaf. Pines, being very inflammable, have suffered badly during the hot dry summer by fire, and it is interesting to notice the repopulation of the clearings. The pines do not appear at first, but the deciduous trees—oaks, beeches, etc.—come up. Then the pines shoot up, and after a few years overshadow the other trees and re-establish the pine growth.

A very hearty vote of thanks was accorded to Mr. Addey for his very interesting lecture and for the series of slides projected on the screen in illustration of the subject.

AT the 565th Ordinary Meeting of the Club, held on December 13th, 1921, Mr. Robert Paulson, F.L.S., F.R.M.S., Vice-President, in the chair, the minutes of the meeting held on November 8th, 1921, were read and confirmed.

Messrs. Arthur L. Butler, Fredk. William Payne, B.A., James Mein, W. James David Roberts, Alfred E. Harris and Dr. Alfonso Gondolf Hornyold were balloted for and duly elected members of the Club. Eleven nominations were read for the first time.

The Secretary announced that it had been decided to hold no meeting on December 27th, and that at the next meeting, on January 10th, Dr. Tierney would read his paper on "Mosquito Investigation."

Mr. D. Bryce exhibited a specimen of a mite found at Melbourne parasitic on Termites. The Hon. Secretary announced that he had received some copies of Mr. Darlaston's catalogue of microscopical slides. The Chairman then called upon the Hon. Secretary to read Mr. E. M. Nelson's paper, "On the Focus Aperture Ratio." This important subject, said Mr. Nelson, has been dealt with on three previous occasions—by Prof. Abbe, by the R.M.S., and by Mr. Nelson himself. The problem is to suggest the most suitable ratio between the power of objectives and their N.A. If the ratio is too low there is "empty magnification," if too high aberrations are sure to be evident. He found experimentally that the resolving power of the human eye is 1/250 in. at 10 in., and then determined the N.A. necessary to resolve this amount with a given objective, using a $\times$ 10 eyepiece for a long tube or a × 15 for a short. The term "optical index," which is the N.A. × 1000 ÷ initial magnifying power, was introduced, and objectives to conform to the plan must have an optical index of 25 or N.A. ·25 for each initial magnifying power of 10. Mr. Nelson proposed to bring before the Club a power-aperture curve based on his own experience. A series of curves was then shown on the screen, the vertical scale representing power and the horizontal aperture. Mr. Nelson advised beginners to keep to one series of objectives. Low powers should be used when possible, and it is a great mistake to rush after high powers. In conclusion, Mr. Nelson advocated large fields to facilitate finding objects, and pointed out that in measuring magnification it is more reasonable to consider the power of the eyepiece as fixed, and the power of the objective as varying accordingly to the tube length than vice versa.

The Hon. Secretary then read "Notes on Mounting in Sandarac and other Media," by Mr. W. M. Bale, of Melbourne. Mr. Bale's experiments were suggested by Mr. T. E. Wallis's paper, Q.M.C. *Journal*, April 1919. Mr. Bale finds amyl-sandarac medium good for mounting radulae of mollusca. He prefers to use a thickened solution to obviate the need for adding more after mounting to replace loss by evaporation, and when there is no danger of shrinkage mounts direct from methylated spirit. He finds the substitution of methylated spirit (which Mr. Wallis condemns) in place of amyl-alcohol as a solvent for the sandarac satisfactory in use. He has experimented with gum thus (frankincense) as a mounting medium. Its only advantages over Canada balsam are its perfect solubility in alcohol and its lighter colour, but there seems to be some possibility of the formation of crystals. Mr. Bale then dealt with the sealing of fluid mounts. He strongly recommends the use of a cover larger than the cell. The cover being held in place by a tight clip, if necessary, while the excess of mountant is gently squeezed out, and the space between the edge of the cover and the slip having been carefully syringed out and allowed to dry, gold size or other sealing cement is run in. Linseed oil, which hardens very slowly, may be used as a mountant instead of castor oil for crystals, etc. Mr. T. E. Wallis, in commenting on Mr. Bale's communication, said that he preferred amyl-alcohol as a solvent for sandarac because, on evaporation, a homogeneous resin remained, whereas, if it was dissolved in methylated spirit, the residue on evaporation was crystalline. He found the thin solution of much advantage in mounting such objects as whole insects, and he had no difficulty in keeping out dust during the evaporation of the solvent.

The Chairman then called upon Mr. Wallis to read his paper on "Microscopy as an Aid to Analysis." Analysis, said Mr. Wallis, is often regarded as the work of the chemist, but other scientists play their part and the microscopist takes a high place. There is a limit to chemical and physical methods. The material may be in a state of fine division when its structure can be revealed only by the microscope. Microscopical methods are often quicker than chemical, *e.g.* an ointment sent for analysis was at once seen to consist of a fatty base and a starch paste. The microscope is also of great assistance in toxicological work where the available material is a very small quantity, the result being checked chemically. Even a pocket lens is useful for examining seed mixtures in cases of alleged poultry poisoning and seed adulteration, or for the preliminary examination of partly ground poultry and cattle foods. In this way Mexican dried flies or Mexican cantharides have been found in certain brands of chicken spice. Starches form an important group of substances identifiable by the microscope. A woman alleged that someone had tried to poison her by putting powder in her tea ; it was found to consist of maize starch and yellow-coloured particles, *i.e.* custard powder. In another case, some well water was complained of ; it gave good chemical figures, but contained a number of bacteria. A few grains of partly decomposed potato starch were found in the deposit, and on examining the surroundings, the gully into which the pump trough emptied was found to be broken and slop water, including washings of potatoes, had been soaking into the ground about the top of the well. After the gully had been repaired the water was quite satisfactory. On another occasion the composition of an ointment was quickly found to be wheat starch paste mixed with a fatty basis, many of the starch grains being found to be partly gelatinised. In a case of suspected poisoning of a child some pieces of firm slate-grey substance found in the stomach were discovered to be pieces of unripe apple stained by iron phosphate produced by the decomposition of some Easton's syrup tablets which the child had eaten, thinking them to be sweets. Apple pulp may be recognised in jam by finding parts of the endocarp, which has a typical appearance. The study of pond-life finds an important application in the analysis of natural waters, the source of supply often being indicated by the deposit. The access of surface water to a well may be indicated by the presence of water fleas, detritus of vegetation, diatoms or nematode worms, and sewage contamination by a distinct type of bacterial deposit. Polarised light may also be useful, as in detecting the substitution of Phytolacca leaves for Belladonna, which both contain crystals, although of very different forms. The identification of chicory in coffee is another well-known example of microscopical analysis, and distinguishing between the different forms of sulphur in ointment and medicines. A knowledge of the microscopical appearance of fibres is of great importance. The presence of agar-agar in jam is revealed by finding diatoms and sponge spicules. Several other examples were given, and Mr. Wallis concluded by saying that the food and drug analyst in particular needs a good knowledge of microscopical technique, and there are no methods of work and no sphere of microscopical knowledge that he can afford to neglect.

The meeting closed with a hearty vote of thanks to the authors of the papers.

At the 566th Ordinary Meeting of the Club, held on January 10th, 1922, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on December 13th, 1921, were read and confirmed.

Messrs. Edwin Crosk, Robert Henry Marriott, Kenneth Blake, Charles H. Jones, B. Langley Judd, Samuel T. Denning, Herbert Potter, B. Montagu Heyman, J. Drummond Pryde McLatchie, M.D., and Misses Madge Kaye and Vivien Norman were balloted for and duly elected members of the Club. Five nominations were read for the first time.

The Hon Secretary, called upon by the President, said that he had recently visited Mr. Nelson, and found him in very good health and hard at work. Mr. Nelson wished the Club a very prosperous year. The list of nominations by the committee of officers for the coming year was read, and an auditor to act for the members appointed. The Hon. Secretary announced that an Exchange Book kindly provided by Mr. Akehurst was now in the hands of the Club. The Hon. Secretary exhibited an Ediswan "Fullolite" electric lamp on behalf of Mr. E. B. Stringer, of Bromley, which he had found suitable for microscopical use. Mr. Stringer, who was unable to attend the Club's meetings, invited any member interested in photomicrography to visit him. Members should advise Mr. Stringer if they are at any time able to accept his invitation. The Hon. Secretary said that he had had some correspondence with Mr. H. Burrows, who was acting for the relatives of the late John Ward, with regard to a quantity of unmounted material that he had to dispose of. The Secretary had tried several samples of the material and found it very good.

Mr. Withycombe exhibited a larva of *Taeniorhyncus Richardii*, which obtains its oxygen by piercing the roots of water plants with its siphon, and also larvae of *Anopheles plumbeus* and *Finlaya geniculatus*, all from Epping Forest. Mr. N. E. Brown exhibited two photographs of seed vessels of a species of the genus Mesembryanthemum, showing them open and closed, and described their structure. They only open when wetted, and the seeds are sometimes washed out by the rain. The valves are forced open by bands of hygrometric tissue, and the capsules open and close time after time until they are rotten. In some cases Mr. Brown has been unable to discover how the seeds are liberated, as the holes seem too small to permit them to escape.

The President then called on Dr. Tierney to give his lecture on "Mosquito Investigation." Dr. Tierney said that there are over 1,000 species of mosquitoes, of which about thirty inhabit this country, including three Anophelines, which are possible carriers of malaria. The breeding habits of gnats do not vary greatly. The males dance in a swarm, keeping always in the same place, and the females go about singly. When a female approaches the swarm the dance becomes a frenzy, the female darts into the swarm, and after the nuptial flight takes a meal of blood. Egg-laying then begins, the eggs hatch, and development into larva, pupa, and imago follows. The eggs hatch in from two to four days. Anopheline eggs are laid singly on the surface of the water, and have floats which prevent them from sinking. The eggs of Culicines and of Theobaldia are laid in rafts of from 2 to 400 eggs, which float. Some species will lay their eggs on a moist surface, but no mosquito's eggs can resist desiccation. The larvae of Culex are provided with siphons, by which they pierce the surface film and obtain oxygen. Anopheles larvae have no siphons; they float at the surface and breathe by means of two stigmata, flotation being assisted by a series of palmate hairs. The larva of Taeniorhyncus obtains oxygen by piercing the roots of water plants with its sharp-hooked siphon. Dr. Tierney then showed a diagram of the larval heads of the three British species of Anopheles, *maculipennis*, *plumbeus*, and *bifurcatus*, and pointed out the differences. The pupa has neither mouth nor vent, and the pupal stage usually lasts two or three days. Perfect insects had emerged from pupae kept on damp filter paper, but if the paper is dry, they die. If creosote is put on the water containing nearly mature larvae, or even if a shower of rain falls on the surface of the water, the larva changes more rapidly into the pupal state, and the duration of the pupal stage is shortened. The impregnated females of Culex hibernate on dark walls, etc.; they frequently congregate in the tropics on dark clothing, and many may be found in old boots. White clothes are avoided, probably because the insects would be more easily seen. Only the female mosquitoes suck blood. Culex is distinguished from Anopheles by its short palps, those of Anopheles being practically as long as the proboscis. The spots on the wings of *Anopheles maculipennis*, caused by groups of scales, are also present in Theobaldia. Culex and Anopheles may be distinguished by their resting positions, Anopheles keeping the abdomen in the line with the proboscis, while Culex assumes a more humped position. *C. pipiens* and *A. maculipennis* are domesticated species, while *A. bifurcatus* and *A. plumbeus* live in the open. The fertilised female of *A. maculipennis* hibernates in cowsheds, cellars, etc., and emerges from hibernation in March. Its favourite breeding places are the shallow margins of weedy (not foul) calm open waters. *A. plumbeus* is a sylvan species, and lays its eggs only in the water in tree holes. Eggs laid in autumn do not always hatch until the following spring. This species also hibernates as a larva. Dr. Tierney then described the vessels used for breeding purposes. Glass jars half filled with water and having gauze covers are used, the pupae being separated from the larvae every day. The imagines take an hour or two to dry, and they are allowed to stand on some suitable support in a bottle or large test-tube. They may very conveniently be kept in wide-mouthed bottles with hollow stoppers. These are kept upside-down, the stopper being filled with water on which floats a thin piece of cork somewhat smaller than the stopper, with a piece of filter paper on it. The eggs will be laid on the paper. The bottles should be kept in a dark cupboard, and on the first or second day the males will be found dead on the paper. Mosquitoes may be fed on dates, raisins, bananas, or blood. By means of diagrams Dr. Tierney then pointed out various details of the anatomy of mosquitoes, and described his method of dissection. He uses two straight surgical needles, which have sharp edges, and dissects in ½ per cent. salt solution. The insects should be kept until the stomach is free from blood—*i.e.* when the ventral surface is free from blackness. They are best killed by concussion, which is effected by shaking them up in a test-tube. The viscera are removed by making a nick each side as near the tail as possible, then steadying the thorax with one needle, while with the other the tail is drawn away, bringing the viscera with it. The salivary glands are obtained by pulling off the head in a similar way. The biting mechanism was illustrated and described, and Dr. Tierney then passed on to the consideration of the development of the malarial parasite. The life-cycle of the parasite is passed partly in the human host and partly in the body of the adult mosquito. The malaria plasmodium is never passed on by the female mosquito to her offspring. In the tropics, where human reservoirs and mosquitoes abound, there is no break in the life-cycle. In temperate zones the continuance of the cycle depends upon three factors : (1) The period of temperature high enough to incubate the plasmodium in the body of the mosquito ; (2) the period during which the organism can linger on in the system of the human host ; (3) the prevalence of mosquitoes when recrudescence occurs. Dr. Tierney said that two-thirds of the preventible diseases in the tropics are insect-borne, and that the conquest of the tropics involves the conquest of insect-borne disease. Human civilisation advances only as far as our knowledge of the rôle which insects play in the dissemination and transmission of disease, and this rôle is not confined to the tropics. Our own house-fly, flea, bug, mosquito, etc., all play an important part, and are equally dangerous in their spheres. The meeting closed with a hearty vote of thanks to Dr. Tierney for his lecture.

At the 567th Ordinary Meeting of the Club, being also the 56th Annual General Meeting, held on February 14th, 1922, the President, Dr. A. B. Rendle, M.A., F.R.S., in the chair, the minutes of the meeting held on January 10th were read and confirmed.

Messrs. Harold P. Wiggins, George Manson France, George Barringer, Fredk. G. Francis and Edward Ernest Warr were balloted for and duly elected members of the Club. Four nominations were read for the first time.

The officers and four members of the Committee were elected for the coming year. The Secretary announced that at the meeting on March 14th Mr. B. S. Curwen would read a paper on "Mounting in Glycerin with Wax Seals, with special reference to Entomostraca," illustrated by slides and experiments. The Treasurer and Secretary presented their reports, and in moving and seconding their adoption Mr. J. Milton Offord and Mr. A. E. Hilton made special reference to the retiring President. Dr. Rendle has been President for five years, and only on very few occasions has he failed to take the chair at the meetings. He has led the Club through the very difficult war period, and when the Club left Hanover Square it was entirely due to his kindly interest in its welfare that a temporary home was found for the library at the Natural History Museum. The members testified by acclamation their high appreciation of Dr. Rendle's valuable services.

Dr. Rendle then asked the newly elected President, Mr. D. J. Scourfield, F.R.M.S., F.Z.S., to take the chair. Mr. Scourfield said that he took up his new office with mingled feelings of pride and humility. He felt proud that his fellow-members had thought him worthy to occupy the position, but he realised the difficulty of following those who had occupied the presidential chair before him. The new President having been welcomed with acclamation, Dr. Rendle delivered his annual address. It was now five years, he said, since he was introduced to the Club. He would always remember with pleasure these years of co-operation with the committee and of association with the members. At the close of another lustrum, said Dr. Rendle, one is apt to look back in review. He was elected to the presidency at one of the most critical periods of the war, the time of nocturnal air raids, darkened streets, and diminished travelling facilities. In spite of these difficulties the interest of the meetings and the attendance of those who were free to come was well maintained. During the last five years there had been two changes in the secretaryship. Dr.

Rendle paid warm tribute to Mr. Burton and Mr. Maxwell, and expressed the hope that Mr. Wycherley might long be able to occupy what is by far the most exacting position in the Club. It spoke well, he said, for the vigour and healthy condition of the Club that it was able to fill so readily and efficiently this post of difficulty whenever occasion arrived. These repeated changes on the right of the presidential chair, said Dr. Rendle, would make his period of service seem unduly long were it not for a wholesome corrective on the other side. Secretaries may come and go, presidents may assume the chair and fall back into obscurity, but our Treasurer stands fast, a symbol of permanency where all else is changeable. The last few years have been difficult ones for treasurers of societies, and it is not many who have been able to carry on and carry on successfully, as has Mr. Perks, on a pre-war subscription.

Dr. Rendle then referred to the eviction of the Club from Hanover Square. Although we are grateful to the Medical Society for their hospitality, the difficulty as to our library remains, and is a matter of much concern to the Committee. In the work of inquiry and negotiation with regard to suitable premises our Treasurer has been especially helpful and keeps a very sharp look-out. In order to make it possible to carry on the work of the Club without raising the subscription it has been necessary to cut down the Journal very drastically, and it is partly due to the generosity of contributors that it has not been further reduced. This is a very serious state of affairs, especially as regards country and overseas members, who cannot attend the meetings. An efficient lending library and a publication which is a vigorous index of the Club's activities are especially necessary to the country members. These matters have been carefully considered by the Committee, but they have been disinclined to take any action which should prejudice the admission to the Club of the young workers in microscopy. It is, however, strange how matters which have been perhaps for a long time burning questions are suddenly settled. The admission of women to the Club is an instance of this. An encouraging feature of our meetings, said Dr. Rendle, has been the increasingly active part taken by some of our younger members. After a brief review of the subjects dealt with by the Club, Dr. Rendle referred to the gossip meetings. A suggestion was recently made that some kind of programme might be arranged to occupy some part of the time or space of these meetings, but it was felt that it would be a pity to interfere with their informal character, which affords opportunity for helpful intercourse among the members. The excursions have been maintained under Mr. Wilson's able guidance, and he is to be congratulated on the series of records achieved. Dr. Rendle impressed upon the younger members the advantages of field work under the guidance of old hands. With regard to microscopic work, he emphasised the point that the production of clear and instructive preparations and photomicrographs should be only means to an end. In many cases where leisure is limited the microscope could be little more than a window through which one gazes into another world to one's great joy and mental relief or entertainment. There are, however, many instances where exceptional skill in microscopical technique has been attained, but in spite of adequate leisure the microscope and camera have remained little more than playthings, whereas useful scientific work might be achieved if some definite problem were kept in view. As examples, Dr. Rendle took, first, the study of diatoms, which might consist of the collection of a number of beautiful and interesting organisms, or it might go further and lead to an increased knowledge of form and structure and the description of new forms, or, further, again, to the study of difficult problems in the life processes of the organisms, or by the mathematical study of minute variations light could be thrown on some general scientific problems. As a second example, he mentioned the photomicrographs showing the various forms of pollen grains. A careful comparative study of these forms might throw light on the affinities of groups, or be helpful in the problems of hybridisation, there being great uniformity of the grains in some families and great diversity of form in others. The origin of this diversity is a question of special interest, and in this connection Dr. Rendle proposed to examine briefly the development of the pollen grain. Generally speaking, pollen grains are derived from mother-cells by division of the contents into four. The mother-cells arise from sporogenous cells developed from a special layer in the young anthers (archesporial cells). The archesporial cells also give rise to a layer of "tapetal" cells, which are rich in food material, and act as a nurse layer during the development of the pollen. There are two common modes of division. Simultaneous division where the two nuclear divisions occur before any walls are found is more characteristic of dicotyledons. In the successive method, most frequent amongst monocotyledons, a wall follows the first nuclear division, forming two hemispherical cells, which again divide equally. A very variable amount of the hypodermal layer of the young anther may become archesporium. The primary sporogenous cells directly or by division produce the mother cells; in some cases they become mother-cells without division, and in some orchids each primary sporogenous cell forms a well-defined mass of mother-cells, a massula separated from its fellows by thicker walls. The ultimate form of the pollen grains is to some extent determined by these differences in the method of formation. Irregularity in the number of divisions of the mother-cell may give rise to more or less than four microspores. Dr. Rendle described several ways in which this may take place. Each of the four young microspores (pollen grains) becomes invested by a separate wall. This soon becomes differentiated into two layers, the inner of pure cellulose, and later developing the pollen tube, the outer cutinised and often sculptured, generally leaving spots for the exit of pollen tubes. A single point of exit occurs in most monocotyledons and a few dicotyledons, while in most dicotyledons there are two or more points of exit. In the family Cucurbitaceae and in the Passion flower lid-like pieces of the outer wall become detached. The origin and development of the walls of spores is a problem that needs further investigation. The character of the pollen is in some cases determined by the ultimate degree of separation between the grains. Generally they are entirely free at maturity, forming a powdery mass, but in some cases they cling together, and in some orchids and the asclepiads they form one mass, the pollinium. In water plants, when pollination takes place beneath the surface, the grains are thread-like, while in wind-fertilised plants they are small and dry, the sculptured and adhesive grains being characteristic of insect-pollinated plants. Thus there is some relation between the form of the pollen grain and the habit of the plant, but when the influences of method of development and habit are eliminated there still remains a wide field for investigation as to the meaning or causes of the wonderful diversity of the mature pollen grain. In the case of early flowering herbs and catkin-bearing trees the pollen is fully formed while the ground is still frozen. The preparation of series of sections of the catkins of our native trees would afford an interesting study in the development of pollen. The various points referred to in the development of the microspores or pollen grains were illustrated by a series of lantern-slides. The meeting closed with a very hearty vote of thanks to Dr. Rendle for his interesting address.

The following Officers were elected for the year 1922–23:

President	D. J. Scourfield, F.Z.S., F.R.M.S.
Vice-Presidents	A. B. Rendle, M.A., D.Sc., F.R.S. David Bryce R. Paulson, F.L.S., F.R.M.S. J. M. Offord, F.R.M.S.
Hon. Treasurer	F. J. Perks
Hon. Secretary	S. R. Wycherley, F.R.M.S.
Hon. Secretary for Foreign Correspondence	E. K. Maxwell, F.R.M.S.
Hon. Reporter	A. Morley Jones.
Hon. Librarian	C. S. Todd
Hon. Curator	C. J. Sidwell, F.R.M.S.
Hon. Editor	A. W. Sheppard, F.L.S., F.R.M.S.

Of the Committee the following members had not served during the preceding year:

C. Tierney, D.Sc., M.S., F.R.M.S.
C. H. Caffyn, F.R.M.S.
F. E. Cocks.

At the 568th Ordinary Meeting of the Club, held on March 14th, 1922, the President, Mr. D. J. Scourfield, F.Z.S., F.R.M.S., in the chair, the minutes of the meeting held on February 14th were read and confirmed.

Messrs. Reginald J. Ludford, B.Sc., Ph.D., F.R.M.S., Charles Edward Green, Robert Hagelstein and W. Charles Davies were balloted for and duly elected members of the Club. Six nominations were read for the first time.

The Secretary announced that two slides had been presented to the Club, one of a spider's head, by Mr. Offord, and one of mites parasitic on termites, by Mr. Williams. A letter was read from

Mr. Jackson, who is in charge of the Plaistow Red Triangle Club, asking if a few members could arrange to give a microscopical exhibition at the Club, which is in the East End and has 1,500 members. Mr. Russell very kindly consented to arrange for such an exhibition, and any members able to help should communicate with him. The Secretary announced that he had asked Messrs. Ogilvy & Co. for some descriptive pamphlets of the lamps that were used at their microscopical exhibition at the last gossip meeting, and distributed some that he had received. Messrs. Ogilvy's exhibition was very much appreciated by the members. Various objects were beautifully shown under about nine microscopes, ranging from the highest powers down to the lowest. Perhaps the most interesting exhibit was a slide of living trypanosomes shown by dark-ground illumination. The Hon. Secretary announced that at the meeting on April 11th Mr. J. Wilson would give " A Short Account of the Genus Closterium," and Mr. N. E. Brown an address on " Imitative and Windowed Plants." The Hon. Secretary said that he had been trying the Ediswan " Fullolite " electric lamp for microscopical work, and found it very brilliant. He exhibited a metal lantern that he had made to screen the light from the observer's eyes, and also to provide facilities for reducing the light by means of screens. The President exhibited a young *Cristatella mucedo* hatching out from the statoblast. He had been examining Cristatella under a high power, and had noticed several points of interest. The true direction of the currents of water caused by the cilia of the tentacles is down towards the mouth and out between the tentacles. Fine setae were found to project from the sides of the tentacles towards the adjacent ones, and the inside surfaces of the tentacles were found to be covered with fine hairs. The membrane of the calyx may be seen to extend over the outer sides of the tentacles.

Mr. B. S. Curwen was then called upon to read his paper on " Mounting in Glycerin with Wax Seals—with special reference to Entomostraca." Glycerin, said Mr. Curwen, is a colourless, odourless, viscous liquid miscible in all proportions with both water and alcohol, but insoluble in ether. Its melting-point is 17° C., and its boiling-point 290° C. when pure. Glycerin is very deliquescent, and the absorption of even a small amount of water will prevent crystallisation at temperatures much below 17° C. Its refractive index is 1·47; it forms a suitable mountant for many algae, insects and crustacea, and is of special value when it is desired to retain the natural colour. Carbonate of lime is soluble in glycerin, so that it must not be used for calcareous objects. Glycerin is a difficult substance to seal. Prof. Birge, an American authority on Entomostraca, recommends their being mounted in glycerin and sealed by paraffin wax of low melting-point. Mr. Curwen found paraffin wax unsuitable, as it contracts when solidifying and does not adhere well to glass. After trying about forty different wax compounds, he adopted a material known as soft red wax. The composition appears to be beeswax with a small proportion of Venice turpentine and a red dye; it is used as a temporary adhesive for experimental puposes, and may be obtained in sticks from dealers in chemicals and scientific apparatus. Mr. Curwen then described the method of mounting. Entomostraca, or water insects, are killed by heating the water until motion ceases. They are then transferred to a 25 per cent. solution of glycerin in distilled water; pipettes, needles, brushes, bristles and small feathers being used for different classes of objects. The pin feathers of a woodcock mounted in a handle are very useful for large Entomostraca, etc. After at least twenty-four hours in the 25 per cent. solution most of the smaller Entromostraca can be mounted in pure glycerin, but the large forms, also algae and most insects, require 24 hours in 50 per cent. and 24 hours in 75 per cent. before mounting in pure glycerin. The mounting may be done in 50 per cent., 75 per cent., or 100 per cent. glycerin, but 100 per cent. should be used where possible, as it is easier to manipulate. The following items are required for mounting:—(1) Filtered glycerin that has been allowed to stand to eliminate air bubbles, in a bottle having a glass dropping rod passing through a rubber cork. (2) Slips and 3/4 in. covers. The slips should be thin to avoid overheating the objects when sealing. (3) Wax discs about 1/16 in. thick cut from the stick and then cut in halves, the amount of wax in a semi-disc being about enough for an average seal. Thin slices melt easily before the object is unduly heated. (4) An assortment of squares of card or celluloid of various thicknesses about 1/32 in. square. (5) A spirit lamp with a small pointed flame. (6) Forceps, needles, and other dissecting tools and a dissecting microscope. The procedure was then described, specimen slides being made on the table of the epidiascope and projected on to the screen during the various operations. A drop of glycerin is placed in the centre of a slip, the objects are withdrawn from the store solution and arranged in the drop, particles of dirt or bubbles being lifted out with a stout needle. Thin card squares are then placed so as to form an equilateral triangle with the drop of glycerin in the middle. The squares should be placed so that they will be fairly near the edge of the cover, and one should be equidistant from the sides of the slip. Near this square is placed the semi-disc of wax, the slip is held horizontally over the spirit lamp and slowly rotated so that the flame travels round under the periphery of the cover glass. As soon as the wax has run in, remove the flame, and in a few seconds the wax will have set, so that the surplus may be scraped away and the slip wiped clean. The placing of the wax close to the card square prevents the cover tilting as the wax runs in. Twenty or more small objects may be arranged symmetrically in a drop of glycerin, and subsequent operations will not disturb them. Several drops of glycerin may be mounted under one cover, and the wax will isolate and seal them ; in this case a card square should be put between each drop and the next. If it is desired to raise the cover glasses at any time, slides may be left unringed, but for greater permanency several coats of gold size should be applied. Covers may easily be removed from unringed slides by cutting through the wax with a thin sharp knife or safety razor blade. Slides should be kept in a warm place—*i.e.* do not let the temperature fall much below 50° F. They should be examined periodically, and if any signs of want of adhesion between the wax and the glass appear, the slide may be gently heated until they disappear without disturbing the ringing cement. Mr. Curwen said that out of 500 slides he had made by this method during the last two years, only thirteen had been scrapped owing to faults developing. Mr. Curwen exhibited an electric heater for running in the wax, consisting of a coil of nichrome wire, through which an electric current could be passed, bent into a circle and attached to a plate of mica. After the paper had been read, a series of photomicrographs of objects mounted by the method described was shown on the screen. The subjects chosen were mostly Entomostraca, but the wider application of the method was indicated by a few photographs of other specimens mounted in the same way.

The meeting closed with a hearty vote of thanks to Mr. Curwen for his valuable contribution to practical microscopy.

Since the above paper was read, certain modifications which at that time were in the experimental stage have been developed. The most important is the substitution of balsam for wax as a sealing agent, the advantages being greater permanency and the avoiding of the necessity for heating the slide. Balsam in xylol has been found to be most suitable, and this is run in round the cover-glass by means of a dropping rod. In this case metal or celluloid spacing pieces are preferable to card, as the latter contains air which issues as bubbles when immersed in xylol balsam. The only disadvantage of the method is the fact that an object once mounted cannot be readily dismounted as with the wax.

During the present year about 800 slides have been sealed with balsam and there are no failures of any sort to report. The xylol balsam will harden at the edges in about a week sufficiently to enable the cover-glasses to be gently cleaned and the slides carried about. Gold size has also been used as a seal instead of balsam, but it is not considered to be so satisfactory as there is evidence of some action at the boundary between the gold size and the glycerin.

My brother, A. J. Curwen, has discovered that globules of pure water or formalin water, copper acetate solution, etc., can be readily sealed in the same manner by first turning a ring of xylol balsam on the slip of the diameter of the globules when compressed by the cover-glass. The effect of this ring is to prevent the globule of water being shifted by the balsam when running in. A considerable number of successful mounts of algae have been made in this manner. Mr. Room has been sealing glycerin with balsam or gold size and using three small disks of red wax for spacing which can be compressed by pressing on the cover-glass until the desired thickness is obtained. Care would have to be taken to avoid compressing one spacing disk more than another, as it is, of course, essential that the cover should be parallel to the slip in order to avoid displacement of the globule.

AT the 569th Ordinary Meeting of the Club, held on April 11th, the President, Mr. D. J. Scourfield, F.Z.S., F.R.M.S., in the chair, the minutes of the meeting held on March 14th were read and confirmed.

Messrs. Kenneth J. Lucian Boxwell, W. T. C. Goulden, Royden Cobden Wale, M.Sc., Thomas W. Bray, James Sarvent and Edward Earle were balloted for and duly elected members of the Club. One nomination was read for the first time.

The Secretary announced that at the meeting on May 9th Mr. Cuzner would give "A Short Account of Some Varieties of Marine Zoology." The Hon. Secretary then read a "Note on Glycerin as a Mounting Medium," by Mr. E. D. Evens. Mr. Evens dealt with the alleged solvent action of glycerin on calcareous structures. The point is mentioned in the 1901 edition of Carpenter's book, and seems to have been copied from one book to another without verification. Mr. Evens has found no evidence of any solvent action. He thinks that possibly the glycerin in use in Dr. Carpenter's early days may have been acid, as it was not so pure as that prepared by modern methods. Mr. Evens gave examples of various calcareous objects that he had himself mounted in glycerin, and which so far appeared unaffected. He said that if a minute amount of precipitated chalk was added to glycerin, sufficient to make it opalescent, the mixture might be boiled without the milkiness disappearing, as it would do if solution took place. Mr. Evens thought the matter was worthy of further investigation on account of the value of glycerin as a mounting medium.

A short note by Mr. Nelson on "A Dark-ground Stop for Pond-Life" was then read. Mr. Nelson said that in some cases, when examining pond-life with dark-ground illumination, the image of the spider carrying the dark-ground stops appeared in the bodies of flagellates, etc. This trouble, which does not occur with balsam-mounted diatoms, may be satisfactorily overcome by using a glass disk instead of the wire spider, having a central hole into which is fitted a pin, or stops may be used consisting of glass disks having black patches painted on them by means of a turntable.

The Hon. Secretary announced that the club had received a very valuable gift from the father of a late member of the Club, Mr. B. Tryon. It was Mr. Tryon's wish that his microscopical apparatus should become the property of the Club. The gift consists of two microscopes and a quantity of apparatus, including a set of five Zeiss apochromats, a lamp, and some valuable slides. The thanks of the Club were accorded to Mr. John Tryon for this valuable gift. The President drew the attention of the members to the rule with regard to smoking at the meetings, as complaints had been made that it had not been observed.

The President then called on Mr. J. Wilson to give " A Short Account of the genus Closterium." Mr. Wilson said that he had frequently noticed that at the excursions the majority of the members were content to describe their " finds " as " Desmids," making no attempt to determine the species. He attributed this to the scarcity of literature on the family, but said that since the publication by the Ray Society of the Monograph on the Desmidiaceae by the Wests, identification had been considerably facilitated. He proposed to deal only with the genus Closterium. Desmids are minute plants, bright green, and of great diversity of form, and are found only in fresh water. Those of the genus Closterium are cylindrical, and attenuated from the middle towards the extremities, and all are more or less curved. They have an inner cell-wall of pure cellulose, and an outer one more thickened, often brownish and impregnated with various salts. The cell-wall is either smooth or ribbed in various ways. These characteristics are of specific value, but the shape of the cell is more important. In Closterium there are two chloroplasts, a central nucleus, and a vacuole at each end of the cell containing moving granules. The position of the pyrenoids in the chloroplasts is a distinguishing feature. The Desmid is enclosed in a mucilaginous sheath, which it secretes. Desmids multiply in three different ways. (1) By cell division: When the nucleus divides, a cell-wall is formed, and after separation each half of the Desmid grows a new semi-cell, thus regaining its characteristic shape. (2) Conjugation: In this case two cells surround themselves with mucilage, and the contents pass out from the middle of each and coalesce, forming a zygospore. The zygospore ultimately divides twice, and forms two protoplasts, which eventually burst the cell-wall, and when free rapidly grow and assume the usual shape of the species. Desmids move towards the light, and advantage is taken of this fact in separating them from the sediment with which they are usually collected. Desmids are found in all sorts of pools, from lakes to the water in cart tracks. They are often found adhering to submerged plants, and especially to the sphagnum in bogs. In Wests' Monograph sixty species and thirty-six varieties of the genus Closterium are described. By the aid of photographs of specimens projected on the screen and drawings on the blackboard, Mr. Wilson pointed out the distinguishing features of some members of the genus. He said that the length and breadth of the cell was an important feature in the determination of the species, and that it was well to follow Wests' advice and make careful drawings of any doubtful specimens. Mr. Wilson concluded his remarks by expressing the hope that some of the younger members of the Club would pursue the study of this very beautiful and interesting family. A hearty vote of thanks was accorded to Mr. Wilson.

Mr. N. E. Brown described some "Imitative and Windowed Plants." In 1811 Burchell, in his travels, states that he picked up what looked like a curiously shaped pebble and found to his surprise that it was a plant, which turned out to be a new species of Mesembryanthemum—*viz. M. turbiniforme.* Burchell made drawings, but collected no specimens, and nothing more was seen of the plant for more than 100 years. Mr. Brown wrote to various South African botanists with a view to obtaining specimens, and in the autumn of 1918 Dr. Pole Evans, chief of the Botanical Survey in South Africa, undertook to look for it. He found the place where Burchell had seen it, and learned that the inhabitants knew it as the "cow's-hoof plant." Eventually a boy from a Dutch farm found him five specimens. Photographs of the plants growing in their natural surroundings were shown on the screen; they were very difficult to distinguish from the surrounding stones. Dr. Marloth has related how Mr. Hammond Took was astonished to see yellow flowers growing on what he had mistaken for pebbles on a piece of ground he crossed daily. Which demonstates how closely these plants resemble the stones they grow among. The plants have two leaves which are thick and fleshy, and whose flat tops barely project above the ground. Between the leaves is a cleft through which the flower grows. In this country, owing to the lack of sun, the plant comes almost out of the ground. At the base in the inside of the plant is a bud which grows and eventually fills up the whole of the interior of the fleshy leaves, absorbing their substance so that they dry up to a mere skin, through which the new growth emerges, and the skin is at last blown away. There is practically no chlorophyll at the exposed surface of the leaf, but the chlorophyll-bearing cells are arranged inside the underground outer surfaces of the leaves, except for a few on either side of the central cleft. The exposed surface of the leaf consists of cells infiltrated with carbonate of lime crystals to form a protective screen for the chlorophyll, and all the light that reaches it passes through this semi-transparent window. The rest of the plant consists of clear water-filled cellular tissue. Mr. Brown said that there were about twenty "windowed" plants, and that they were all natives of South Africa, but that they were not all members of the genus Mesembryanthemum. In answer to a question, Mr. Brown said that he knew of no other plants that mimicked stones, but that there were many that imitated other plants. The Mesembryanthemum plants were so well hidden that even the ostriches, which would eat anything, had failed to exterminate them. The members expressed their appreciation of Mr. Brown's interesting address, and of the very fine photographs of the plants in their native habitat projected on the screen.

At the 570th Ordinary Meeting of the Club, held on May 9th, the President, Mr. D. J. Scourfield, F.Z.S., F.R.M.S., in the chair, the minutes of the meeting held on April 11th were read and confirmed.

Mr. George S. Coverley was balloted for and duly elected a member of the Club. One nomination was read for the first time.

The President announced the death of Mr. Turner, an old member and a Trustee of the Club. The news was received with much regret, and a vote of condolence with Mrs. Turner was passed. The Hon. Secretary announced that at the next ordinary meeting on June 13th Mr. E. K. Maxwell would read a paper on "Some Tube-dwelling Rotifers," and Mr. F. N. Davidson would give a demonstration of the "micro-telescope" and "super-microscope." Dr. Hornyold very kindly sent for distribution to the members some tails of elvers stained with alizarin. A few drops of a saturated solution of alizarin in 90 per cent. alcohol are added to 75 per cent. alcohol, and the tails are left in this solution for a couple of days. Excess of stain is removed by 90 per cent. alcohol. Only the skeleton is stained, but the muscular tissue may be stained by adding to the alizarin a weak solution of Bismarck brown.

A paper by Mr. C. D. Soar on a species of Hydracarina found at Bear Island by the Oxford University Expedition to Spitsbergen, 1921, was taken as read, and the Secretary read two notes by Mr. E. M. Nelson. In the first note Mr. Nelson said that in setting up a dark-ground illumination with a bull's-eye (say for pond life) it was usual to place the flame at the principal focus of the bull's-eye, so that parallel rays might fall on the back lens of the substage condenser. Therefore the image in the object-plane would be the bright disk of the bull's-eye. If the bull's-eye is placed a little farther from the edge of the flame, so that the image of the edge of the flame falls upon the back lens of the substage condenser, then the image on the object-plane will be a magnified image of this flame, and when that is cut out by a stop of proper size, the brilliancy of the illumination will be considerably increased. The sharpest, but not the brightest, image is obtained when a bull's-eye is dispensed with, and the flame image focused upon the object-plane by the substage condenser. A little difference in the size of the stop makes a good deal of difference in the brightness of the illumination, especially if the power of the substage condenser is high.

Mr. Nelson said that for transmitted light, especially with high powers, the screen he had used for many years was one composed of three glasses, to which a fourth in special instances was added. This he preferred to all others. In the Wratten scale it comes between the Nos. 44 and 45, which are both good screens for visual work upon diatoms. With bacteria the conditions are quite dissimilar, so he used entirely different glasses, sometimes as many as five. These, however, can be matched by Wratten's 58 + 65A, which he thought gave perhaps a better result than the glasses. Mr. Nelson's other note described how to distinguish tobacco leaves from those used as adulterants, of which there are about forty. The tobacco is soaked in hot water for a quarter of an hour and then a fragment is examined in a compressor with a drop of water. If glandular hairs three or four cells long are present, having at the tip an oval cluster of some six cells filled with a yellow substance, the plant is tobacco. The thanks of the Club were accorded to the authors of the above notes and papers; also to Mr. Russell for having organised an exhibition at the Red Triangle Club that had been much appreciated.

On the recommendation of the Committee, Mr. G. T. Harris, well known for his work on the Desmidiaceae, was elected an Honorary Member of the Club. The President then called on Mr. E. Cuzner, to read his paper, "Some Studies in Marine Zoology." Mr. Cuzner said there might be some that were not familiar with the varied and beautiful forms of life that could be found in the rockpools and open sea, and that he proposed, with the aid of lantern-slides, stereo-photomicrographs, and prints, as well as many of the objects themselves that were shown under microscopes in the meeting room, to describe a number of marine zoological specimens from the lowest forms of life to the vertebrates. A large number of lantern-slides were shown on the screen, most of which were photomicrographs taken by darkground illumination. The amoeba, said Mr. Cuzner, was generally considered to be the simplest self-contained unit of animal structure. Many beautiful microscopical marine forms are similar to it in composition and structure so far as has yet been discovered, but they secrete for their protection beautiful calcareous or siliceous skeletons. The best known of these creatures are the Foraminifera and the Polycistina. In the next group—Acanthometra—there is no enclosing shell, but a spicular skeleton, and in the beautiful *Collozoum punctatum* we have a colonial form composed of masses of similar individuals of this type. The last of the protozoa to be described was *Noctiluca miliaris*, to which the phosphorescence of the sea is often due, and Mr. Cuzner then passed on to the Coelenterata, describing the structure of sponges, and showing the variety of spicules found in the group. The coral polyps were represented by several forms, and a series of photographs of sea anemones was shown. A very considerable part of the lecture was taken up by the Hydroida, in which the lecturer was especially interested. The structure of the freshwater hydra, which is the simplest of the hydroids, was described in detail. It belongs to a sub-order that has no marine representatives, but its simple structure forms the basis of all the families of the Hydroida, however diverse may be their forms. The process of reproduction is very varied in the different genera. Sporosacs containing spermatozoa or ova may be formed on the hydroid, or there may be an alternation of generations, and a Medusa may be first budded off to lead a free life and then develop ova and spermatozoa. From the ova ciliated wormlike creatures escape, which, after swimming for a time, settle down and form the beginnings of new colonies. The colonies are formed by the multiplication of the new hydranth until they may consist of hundreds of polyps. It is this process of reproduction that is of such interest to the microscopist. A number of photographs of hydroids were shown on the screen, finishing with the beautiful branching forms Sertularia and Plumularia. The Siphonophora, which are free-swimming colonial hydroids, were described next, and a beautiful group of *Haliclystus octoradiatus* (Scyphomedusae) was much admired. The Echinoderms furnished the microscopist with many interesting objects. The little Grey Brittle Star is amusing to watch in an aquarium, and has the peculiar power of breaking to pieces when touched. The Purple Sun Star and the Gibbous Starlet, the latter being the smallest British species, are both very beautiful objects. Sea-urchins and Synapta are well known to most microscopists on account of the beautiful structure of the spines of the former and the peculiar calcareous plates and anchors that occur in the skin of the latter. The worms form the next large class of the animal kingdom, and many of the marine worms are extremely beautiful in both form and colour. Having shown photographs of the wonderful organs of the barnacles for catching their prey, Mr. Cuzner described a small Pycnogonid that he had found plentifully in South Devon, and, after briefly noticing the Mollusca and their radulae, he passed on to the Polyzoa, which have a certain amount of outward resemblance to the hydroids, but on closer study are found to belong to a much higher group. The highest class of the invertebrates is the Tunicata, of which Botryllus is a genus, species of which may frequently be found on fucus, while Salpa, which has a remarkable life-history, is a free-swimming form that occurs in deep water round the Channel Islands. In conclusion, Mr. Cuzner expressed the hope that his survey of some of the many interesting forms of life that were to be found in the sea would inspire those who visited the coast in the summer with a desire to look for the creatures and study them. The meeting closed with a very hearty vote of thanks to Mr. Cuzner for his lecture and the fine collection of specimens and photographs that he had brought to the Club.

At the 571st Ordinary Meeting of the Club, held on June 13th, Dr. A. B. Rendle, M.A., F.R.S., Vice-President, in the chair, the minutes of the meeting held on May 9th were read and confirmed.

Mr. Douglas G. Howatt was balloted for and duly elected a member of the Club. Three nominations were read for the first time.

The library would be closed during August, and be opened again on the first Saturday in September. Mr. Swanton exhibited a drag fitted with a safety device to prevent its loss in case of entanglement at the bottom of a pond. The end to which the cord is fastened is separate from the rest of the drag, and attached to it by a thin piece of wire. If the tension is too great this wire gives way, and the pull is transferred to the other end of the drag, to which the cord is also fastened. This reverses the position of the barbs so that there is a good chance of the drag freeing itself.

The Chairman then called upon Mr. E. K. Maxwell to read his paper, "Some Notes on Rotifers as a Leisure-time Study." Mr. Maxwell said that he had been unable to find sufficient time or energy under present conditions to prepare a paper that would do justice to the subject he had intended—"On some Tube-dwelling Rotifers"—but he had put together a few ideas that he hoped might prove helpful and suggestive. The great majority of us, he said, become attracted to the microscope for the sake of the pleasant entertainment that it affords, and most of us can hardly hope to become more than intelligent dabblers at any of the many subjects it brings before us. To become expert at any subject involves considerable study and time, and, from his experience, Mr. Maxwell was forced to think, the microscope would, if one got drawn into the vortex of specialisation, prove to be a taskmaster more than a friend. Bearing this in mind, he proposed to consider briefly some of the points that arose in pursuing the rotifer-quest by the amateur. The beginner who wants something that will give him an interesting show is likely to have his attention engaged by the rotifers. The commoner forms are just of a convenient size for a 2/3rd in. with dark ground to give an effective show, with plenty of room in the field for supporting weed to set them off. The lusty vigour rotifers display, quite unhampered by their narrow domain, gives an impression of joy of living and even of a desire to please, so that the idea of restraint is banished. With the 2/3rd in. and dark-ground illumination many species may be identified, and it is a very pleasant way of working through an afternoon's catch. Then, again, there is plenty of scope for high-power work in solving the difficulties of structure. Any rotifer may be identified with a 1/6th in., and such a power is necessary to see the small forms satisfactorily. There is also scope for the highest powers, and a water-immersion with correction collar is a very useful addition to the outfit if the amateur has a really inquiring mind. The water-immersion objective is valuable for examining both live and mounted specimens (the latter being in weak formalin). Mr. Maxwell had never been able to use an oil-immersion objective adequately on any rotifer, alive or dead. As regards specimens, the rotifer hunter is in a more fortunate position than most microscopists, for there is no season of the year in which they cannot be found, provided there is water. The types found vary with the seasons, but there is no season at which none can be found. Mr. Maxwell had even taken floscules and melicerta from under several inches of ice. The best time for rotifers is in the springtime, before the crustacea begin to flourish, when they can be found in suitable ponds, etc., in countless numbers ; but it is not Mr. Maxwell's experience that the greatest variety of species is found in such hosts of specimens. Rousselet was apparently of the opinion that if search were sufficiently thorough it should be possible to find in these islands all, or nearly all, the known species. No slowly moving or still water should be neglected by the rotifer hunter. Little temporary pools, drains at the sides of fields, especially at the foot of grassy, mossy banks, old roof gutters are all worth examination, and on one occasion Mr. Maxwell found a cow-hoof mark, 5 in. deep, swarming with Synchaeta. The Club haunts are good, said the speaker, but he thought the Mitcham Common ponds, unless radically changed by last year's drought, are worth serious investigation. He had found the rare floscule, *F. trifidlobata*, there, and saw what appeared to be a rare species of Apsilus, while there were also many different forms of Oecistes. The best place for tube-building rotifers about London in his experience is undoubtedly the Thames at Kingston, Ditton, and Datchet. He had found a great many tube builders there and in great plenty, also Cephalosiphon, Limnias, many forms of Oecistes, and the beautiful colonial form *Lacinularia socialis*, while many of the loricate rotifers which haunt the weed were also present. For the examination of a gathering Petri dishes 4 in. or 5 in. in diameter and 3/4th in. deep are convenient. They are placed on a glass plate supported about 3 in. above the table, underneath which is a concave mirror that can be tilted to give dark-ground illumination for the hand magnifier. The Petri dishes may be used on the stage of a microscope in a vertical position when small forms are to be picked out. Rotifers may be picked out with a pipette which should not be too fine even for small forms and males. In the case of the males, which move quickly, it is best to isolate them in a watch-glass, and then get them into a drop of clean water on a slip. This drop may be reduced, and when small enough the cover should be put on with three pellets of wax as supports, which may be pressed down as much as required. Cavity slips are also useful, and flat tinfoil cells such as Mr. Bryce uses. For identifying rotifers, the most useful book is the German *Süsswasser Fauna*; there is also Hudson and Gosse, and a bibliography may be found in the Synopsis of Harring, giving references to various papers in the Q.M.C. and R.M.S. *Journals*, etc. Mr. Maxwell follows the Rousselet method of mounting, and finds it gives excellent results. Rarities are not too uncommon for the persistent rotifer hunter, and he thinks the difficulty of handling the specimens is the reason that there is still so much to be discovered. Males, which are comparatively rare, should always be looked for. In some species the male only seeks the female when she is just hatching out, so that the speculative amateur may find interest in the habits and customs of a race of creatures who relegate all their matrimonial problems, whenever these rare events occur, to the nursery, and apply themselves to the serious study of vortex motion and hydrodynamics, and, most earnestly of all, to gastronomics, while occasionally specialising in architecture. Besides all the normal healthy forms there will at times be found specimens affected with parasites which are of interest. With the aid of lantern slides Mr. Maxwell then described the various types of rotifers and explained some of the chief points in their structure. Mr. E. K. Maxwell received a very hearty vote of thanks for his stimulating and interesting account of the rotifer-hunter's methods of work.

A paper by D. Bryce: "On Some Rotifera from Spitsbergen," being Report 16 of the Oxford University Expedition to Spitsbergen, was read in title.

The meeting closed with a demonstration by Mr. F. Davidson of his "micro telescope" and "super-microscope." A number of instruments were exhibited, and a series of photographs and lantern slides showing the results that had been obtained by means of the apparatus described. The thanks of the Club were accorded to Mr. Davidson for bringing the apparatus under the notice of the meeting.

FIFTY-SIXTH ANNUAL REPORT.

The Committee feels that there is cause for congratulation on the satisfactory condition of the Club, as shown by the details in this year's report.

During the year 47 new members have been elected. We have lost 10 by death and 9 by resignation, leaving a total number of 523 members, which means a net increase of 28 in the membership of the Club.

The outstanding loss of the Club, and one also that the scientific world generally regrets, is the death of Mr. C. F. Rousselet, who for many years did a great deal of original research work on the Rotifera, and his method of mounting them holds the field to-day as probably the best form of preserving them.

The average attendance at Ordinary Meetings throughout the year has been 78, and for Gossip Meetings 73.

The Club is still finding the accommodation somewhat cramped for its membership, but the Committee has not been successful in finding satisfactory premises elsewhere. The Club is also suffering from the lack of a room available for greater facilities in the exchange of books; but while the fact of our not having them at hand is to be regretted, the Club is still very much indebted to Dr. A. B. Rendle for enabling us to have accommodation in the Botanical Department at the Natural History Museum, South Kensington, for the storing and distribution of books.

The Committee feels that with the retirement of Dr. Rendle from the Presidentship this year, it cannot do other than refer with high appreciation to the great service which he has rendered to the Club during the last five years. The Club has gone forward and increased its prosperity and usefulness, and the Committee desires to express on behalf of the Club its thanks for the liberal services he has rendered.

The papers read during the twelve months have covered a wide field. The principal papers are as follows :—

January.—Charophyta, by Canon Bullock-Webster, F.L.S., F.R.M.S.

February.—The Part played by certain Microscopic Plants in the Nutrition of the Higher Plants, by Dr. A. B. Rendle, M.A., F.R.S.

March.—The Larva of Corethra plumicornis, by S. C. Akehurst, F.R.M.S.

April.—Diatom Structure, by N. E. Brown, A.L.S.

May.—Microscopical Drawing, by C. D. Soar, F.L.S., F.R.M.S.

May.—Light Filters for Visual Work in Microscopy, by J. H. Pledge, F.R.M.S.

June.—Some Facts and Fallacies of Practical Microscopy, by A. A. C. Elliot Merlin, F.R.M.S.

June.—Notes on Parasitic Acari, by Stanley Hirst.

October.—Deep sea Deposits, by A. Earland, F.R.M.S.

November.—Pinus sylvestris, by F. Addey, B.Sc.

December.—Microscopy as an Aid to Analysis, by T. E. Wallis.

December.—The Focus Aperture Ratio, by E. M. Nelson, F.R.M.S.

In addition to the above, we have had the good fortune to have from Mr. E. M. Nelson several short papers on various items of interest in microscopy. Those perhaps of most general interest were his notes on:

Mirrors made of Stainless Steel for the Microscope;

The Use of Golden Syrup as an Immersion Medium for Condensers;

Polarization and N.A.; and

A New Form of Polariscope.

Then we have had two or three exhibits of considerable interest:

A Portable Lamp, exhibited and explained by Dr. J. Tierney;

A Low-power Polariscope, by Mr. Wood;

Method and Apparatus for measuring the Refractive Index of Oils used in Medicine, by Dr. Smart;

The Measurement of the Vertical Dimensions of Objects by the Use of the Graduated Fine Adjustment, by F. Addey, B.Sc.

We were very fortunate in being able to have exhibits on three successive occasions by Messrs. Watson & Sons, Messrs. R. & J. Beck, Ltd., Messrs. Baker & Co., of their general microscopic apparatus. These were shown in the Library adjoining the meeting-room, and proved of considerable interest to members. It is hoped that on some future occasion we may have further exhibits of a similar character.

On behalf of the Members the Committee thanks the Authors for their communications, and we are glad that this year the number of short papers and notes at the meetings has been increased. This is a development which it is desired to foster, and any of our newer members who have anything they think may interest other members should communicate with the Secretary, as comments on actual experiences or investigations are often of practical help to others.

Further, members of the Committee have noticed that in the course of the year several members of the Club have devised adaptations for the more perfect use of their instruments and other novelties and accessories which might be of general interest. If members who make experiments in this direction and find them satisfactory would bring the report of the alteration, etc., of their equipment to the notice of the meeting, such communications would be welcome, as such adaptations by experienced workers may render the instrument more valuable to other users.

This year, again, the Committee has been able to issue only one number of the *Journal*, owing to the still heavy expenses of production. If these expenses materially decrease, it is hoped that two numbers yearly will be issued as in the past.

The Committee wishes to tender its thanks on behalf of the members to the various Officers who have so readily and efficiently carried on the work of the Club, and the Committee expresses the hope that the development of the Club throughout the ensuing year may be such that members, both the older ones and those who have more recently joined, may find in the Club a meeting-ground for mutual development in their study of Microscopy in its various branches.

The Librarian reports that during the year ending December 31st, 1921, the Club's Library has been open for the issue of books on eleven occasions at the Herbarium, Natural History Museum, South Kensington.

About 108 volumes have been issued during this period, a marked increase on the numbers for 1919 and 1920. In addition to the usual periodicals presented by and exchanged with other Societies, the Library has been enlarged by several volumes presented by members, and include :—

Systematic and Descriptive Mineralogy, 2 Vols.
By H. Bauermann. *Presented by F. W. Woodman.*

CHEMISTRY OF FOODS, 2 pts.
By J. Bell. *Presented by W. J. Ireland.*
MINERALS AND THE MICROSCOPE.
By H. G. Smith. *Presented by A. W. Sheppard.*
THE MICROSCOPE IN THE MILL.
By James. Scott. *Presented by A. W. Sheppard.*
ELEMENTS OF VEGETABLE HISTOLOGY.
By C. W. Ballard. *Presented by A. W. Sheppard.*
ALBUM OF MICROPHOTOGRAPHS.
By T. A. O'Donohoe. *Presented by Mrs. O'Donohoe.*

The following have been presented by the authors:

ALGAE FROM HOT SPRINGS IN SPITZBERGEN.
Presented by K. M. Strom.
ALGOLOGICAL NOTES.
Presented by K. M. Strom.
PHYTOPLANKTON FROM NORWEGIAN LAKES.
Presented by K. M. Strom.
FRESHWATER HYDRACHNIDS OF DENMARK.
Presented by O. Lundblad.
DANISH CULICIDAE.
Presented by Dr. Wesenberg Lund.
ÉTUDES SUR LES INFUSOIRES D'EAU DOUCE.
Presented by Dr. E. Penard.
CYSTODISCUS IMMERSUS.
Presented by Dr. Ergato Cordero of Buenos Ayres.
OPALINA ANTILLIENSIS.
Presented by Dr. Ergato Cordero of Buenos Ayres.

Received on subscription:

British Freshwater Rhizopoda and Heliozoa, Vol. V., by J. Cash and G. H. Wailes (Ray Society).
Quarterly Journal of Microscopical Science.

Memoirs, Reports, and Proceedings have been received from:

Academy of Natural Science, Philadelphia.
American Microscopical Society.
Bergens Museum, Aarbok.
Birmingham Natural History and Philosophical Society.
Brighton and Hove Natural History and Philosophical Society.

Bristol Naturalists' Society.
British Association Reports.
California, University of.
Geologists' Association.
Hastings and St. Leonards Natural History Society.
Indian Museum, Calcutta.
Manchester Literary and Philosophical Society.
Manchester Microscopical Society.
Missouri Botanic Garden.
Nuova Notarisia.
Philippine Journal of Science.
Redia.
Royal Dublin Society.
Royal Microscopical Society.
Royal Photographic Society.
Royal School of Agriculture, Portici, Italy.
Royal Society of New South Wales.
Royal Society, Series B.
Royal Society of Denmark.
Société Royale de Botanique de Belgique.
United States National Museum.
Victorian Naturalist.
Wagner Free Institute, Philadelphia.

On his own behalf and on that of the Club, the Librarian expresses grateful thanks to Dr. A. B. Rendle, Keeper of the Botanical Department, for his care of the Club's Library during the past year. The Librarian will be happy to assist and welcome new members whenever they choose to avail themselves of the advantages which the Library affords.

The Excursions Secretary reports as follows: He is pleased to say that the programme as arranged was duly carried out, notwithstanding the unfavourable weather conditions which caused many of the ponds in the neighbourhood of London to be wholly or partly dried up. Eleven Excursions were held, at which the average attendance was 22·0 against the record number 23·0 for the year 1914.

The first Excursion was on April 9th, when, by the kind permission of the Royal Botanic Society, the gardens in Regent's

Park were visited; 53 members were present. The finds were not numerous, but 22 different species of rotifers were collected, including the males of *Brachionus angularis* and *Polyarthra trigla.* Two species of polyzoa were found; these were very scarce.

On April 23rd the Club visited the Eagle Pond, Snaresbrook, and Higham's Park Lake. The former was prolific of Rotifers; 33 different species were identified, including *Euchlanis oropha* and the males of *Brachionus angularis, Epiphanes brachionus, Keratella quadrata,* and *Synchaeta tremula.* At the Lake three species of polyzoa were found.

May 7th, Hanwell, Greenford, and the Canal Bank to Brentford were visited. This was an exceptionally good day. Mr. Cocks collected numerous rotifers, including the males of *Brachionus calyciflorus, Epiphanes brachionus,* and *Polyarthra trigla. Volvox globator* was in great abundance at Greenford, and the rare Heliozoon, *Clathrulina elegans,* was collected by the Secretary.

On May 28th Mitcham Common was visited. Twenty-six members attended this Excursion, and although the ponds were very low, 32 different species of rotifers, including *Squatinella tridentata* and *Melicerta ringens,* were recorded; *Hydra vulgaris* and *H. viridis* were in abundance.

On June 11th Trent Park was visited, and with the exception of the male of *Asplanchna priodonta,* nothing out of the usual was found.

The next excursion was on June 25th to Chingford, High Beach, and Strawberry Hill Ponds. On arrival at Chingford, the water in the Warren Pond was found to be very low, and the party was informed that the ponds at High Beach were dried up, so that was omitted from the programme. A good collection of rotifers was made at Strawberry Hill; 33 different species were collected. The Cuckoo Pits were almost dry; *Conochilus volvox* was again found, but *Volvox globator,* which used to be in great abundance, was scarce.

Richmond Park was visited on July 9th, the rotifers *Ascomorpha volvocicola, Floscularia conifera, Melicerta ringens, Stephanoceros fimbriatus, Mytilina compressa,* were found, but the Slade Ponds were almost dried up.

On July 23rd Totteridge Ponds were visited, but owing to the continued drought and in anticipation of the ponds being dry, only nine members attended. Mr. Cocks was again successful in his list of captures, among which were the males of *Brachionus urceus*, *Filinia cornuta*, *Keratella cochlearis*, and *Polyarthra trigla*.

The next Excursion, on August 13th to Northwood and Ruislip, was attended by only twelve members. At the first pond, which was almost dry, the larva of Anopheles was found to be plentiful, and at the next pond, in which three species of polyzoa had been found on our last visit, not a single specimen was obtainable, although careful examination was made for over an hour.

On August 27th Loughton, Golding's Hill, and Wake Valley Ponds were visited, when Mr. Cocks, on this occasion, identified 62 different species of rotifers, including many rare ones.

The last Excursion was to Hampton Court on September 17th, which is always a favourite. Three species of polyzoa were collected in the Long Water, several water-mites and 35 different rotifers were found.

On the kind invitation of Dr. Leeson, F.L.S., F.R.M.S., the party called at Clifden House, Twickenham, and for the fourth time were entertained to tea by Dr. and Mrs. Leeson.

In presenting this report, the Secretary would like to call the members' attention to the abnormal state of the ponds, and suggest to them to pay special attention to the fauna and flora on their next visit in order to ascertain the effects of the drought. Desmids were conspicuous by their scarcity or absence in all the ponds, especially noticeable at Strawberry Hill, where over 50 species had been collected on our last visit, also at the Cuckoo Pits, where *Micrasterias rotata* and *M. denticulata* were abundant last year, not a specimen was found. Further, he would urge upon the members to make lists of their finds and follow Mr. Cocks's good example, who has recorded no less than 122 different species of rotifer without including any of the Bdelloida.

The Curator reports that during the past year 110 slides have been given to the Cabinets. Although still labouring under adverse conditions, some 800 preparations have been issued to members. The Committee regrets that better accommodation has not been found in the building, so that all sections could be available, thus increasing the usefulness of the Club's comprehensive collections, instead of only part as at present.

Owing to the continued heavy cost of printing and the want of special funds for the purpose, the Committee has reluctantly been compelled to defer printing the new Slide Catalogue, to which reference was made in the last Report. Until this is issued, and proper accommodation for the handling of the slides secured, the full use of the collections must be considerably curtailed.

Mr. Bestow has continued his kind assistance to the Curator in the lending of slides, for which the Committee tenders him its best thanks.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

For the year ending December 31st, 1921.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance from 1920	184	2	3	By Rent	63	0	0
„ Subscriptions	196	0	0	„ Expenses of *Journal*	129	14	3
„ 1 Life do.	10	0	0	„ Postages, etc.	6	15	2
„ Dividends	13	17	0	„ Printing and Stationery	8	9	3
„ Sales of *Journal*	23	18	10	„ Attendant	1	0	0
„ Advertisements	7	0	0	„ Petty Expenses	1	18	5
„ Dividend Bates, deceased	0	3	8	„ Books and Slides	3	15	6
				„ *English Mechanic*	13	15	0
				„ Balance in hand	206	14	2
	£435	1	9		£435	1	9

INVESTMENTS.

	£	s.	d.
$2\frac{1}{2}$ per cent. Consols	334	1	6
Metropolitan Water Board Stock	100	0	0
Metropolitan Stock	100	0	0
$2\frac{1}{2}$ per cent. Annuities, 1905	100	0	0

We have examined the above Statement of Income and Expenditure and compared the same with the vouchers in the possession of the Treasurer and have verified the Investments at the Bank of England and find the same correct.

January 24th, 1922.

J. WILSON
JAMES C. MYLES } *Auditors.*

FREDK. J. PERKS, *Treasurer.*

OBITUARY NOTICE.

CHARLES FRÉDÉRIC ROUSSELET, F.R.M.S.

1854—1921.

It is with great regret we have to record the death of Mr. C. F. Rousselet, who for many years was a familiar figure at our meetings. Rousselet was born at Friedrichsdorf, near Bad-Homburg, in Germany, in 1854, and died on October 15th, 1921, after a long illness of several years. He came of an old Huguenot family and his direct ancestor, Esaïe Rousselet, with his son and daughter, left his home at Perrière, near Soissons, after the Revocation of the Edict of Nantes, about 1685. He and several others, some thirty refugee families in all, reached Switzerland, and thence, following an invitation given by Friedrich II, Landgrave of Hesse-Homburg, in 1687, went to Germany and founded a French Huguenot settlement, afterwards called Friedrichsdorf from the name of their benefactor. Here the descendants of the refugees have continued to live, speaking French as their mother-tongue, to the present day. Rousselet's mother's name was Garnier; she was descended from Jérémie Garnier, a Huguenot refugee from Vitry-le-François, in the Champagne, whose father was a well-known surgeon in Vitry.

Mr. Rousselet came to London in 1873 and obtained a certificate of naturalisation in April 1889. During the years 1881–1902 he was agent in London for the well-known Bordeaux firm of A. de Laze et fils.

Before the publication of Hudson and Gosse's "Rotifera" in 1886, Rousselet had already begun to pay attention to this group of animals. The systematic study of the Rotifera may be said to date from the publication of this book, and Rousselet was not slow to avail himself of its use in extending our knowledge of this interesting group of freshwater organisms. His researches, continued over many years, led to his becoming recognised as the chief authority. His contributions, both systematic and descriptive, were published in the Journals of the Royal Microscopical Society and of this Club; they cover a wide ground and embrace papers on collecting and preserving material, descriptions of new species and census lists of additions to the rotiferal fauna in many parts of the world. His wide circle of correspondents enabled him to considerably increase our knowledge of the geographical range in the distribution of even well-known forms. His descriptive papers were always accompanied by accurate drawings illustrating the specific details necessary for their determination, and in this way he set a very excellent example. His methods of preserving and mounting the material are perhaps better known than his more descriptive work both by workers in this group and in other groups of animals both marine and freshwater. Narcotisation either by his method or some modification of it is now practised in all laboratories where biological work is carried on. The last paper published by him, " Some Further Notes on Collecting and Mounting Rotifera," appeared in our Journal (vol. xiii, JOURNAL Q.M.C., p. 321, October 23rd, 1917), where a bibliography is given of his various papers dealing with this subject, in which he achieved such marked success.

He served the Club for many years in the office of Foreign Correspondent and also as Vice-President, and was a frequent attendant at both our meetings and excursions, where his expert knowledge was always freely available. He was also for many years on the Council of the Royal Microscopical Society, having been appointed Hon. Curator in January 1898 ; he served in this office till December 1916, when his increasing physical disability led to his resignation. His valuable collection of reprints, numbering over a thousand items, is now preserved, for purposes of reference, in the Library of the Royal Microscopical Society; they probably form a unique collection of papers on the subject of the Rotifera.

For permission to use the portrait-block of Mr. C. F. Rousselet illustrating this notice we are indebted to the Editors and Council of the Royal Microscopical Society.

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(It will be understood that the Authors alone are responsible for the views and opinions expressed in their papers.)

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